COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

Vol. XVII FEBRUARY, 1912 No. 2

A MACHINE SHOP WITHOUT COMPRESSED AIR

BY FRANK RICHARDS.

A month or two ago I made a little call at a machine shop with which I was quite familiar for several years ending about a quarter of a century ago. It is not what you might call a big shop; I should guess that it employs less than a hundred hands all told. It was a prosperous business when I knew it intimately—it was growing in those days—and its prosperity has not deserted it in all these years, but it has done little if any growing since.

I was talking with the superintendent and among other things I said something about compressed air and the multiplicity and variety of employments it has in these days—but I used only the handy words of everyday talk—when it came out, really to my surprise, that this shop has absolutely no compressed air in use nor any means of supplying it. I said to myself at once: "That explains why the concern hasn't been growing." A shop needs compressed air to breathe to develop in it full activity and push. The absence of the compressed air implies the lack of other facilities of business which alert management, not necessarily and consciously "scientific," would be bringing together for the increase of efficiency and output.

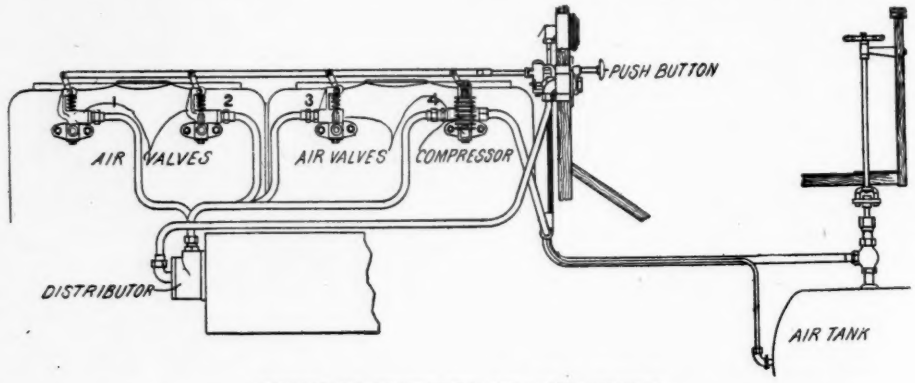
Why, I thought in a minute as I was talking, there is a single job in that shop which alone would pay for the installation and maintenance of compressor, receiver, piping and all appurtenances. A single air hoist would do it. There is a special machine that they build in considerable quantities and which in the assembling involves the hoisting of two or three tolerably heavy pieces; and then in testing these machines there are peculiar conditions which make it necessary to take each apart and put it together two or three times. Think of doing the hoisting with a chain hoist and trolley on a short run of over-head track. The use of this one hand operated hoist, with all which it implies as to means and methods, necessitates an additional helper on the job, and it means also much slower movements for the hoisting and lowering operations. Then they have some large tools, a big planer, some big lathes, a boring mill and no air hoists for them. This is saying nothing about the pneumatic tools, hammers, drills, etc., which the shop would have use for, and the special applications of the air which would inevitably develop if the air was handy.

Not to go into figures in detail, a cost of one dollar a day would liberally cover the interest upon the cost of installation, the maintenance and the power cost of operating, a compressed air equipment for such a machine shop as we have here in mind. Where is the shop which can afford not to spend the dollar? There is absolutely not the slightest suggestion of experiment in the matter, as the value of compressed air as a shop helper has been demonstrated wherever it has been employed. Its record in this respect is unique. No one has ever heard of any shop once adopting the use of compressed air and afterwards discarding it.

There are in fact comparatively few shops now which have not an air compressor as a component of their equipment, and where any such shops are found they are never railroad shops, because there the handy air brake pumps, which are far from the ideal for general shop use, have given them all an opportunity of sampling the compressed air service, and the air itself has done the rest, so that the railroad shops are now among the best customers of the builders of up-to-date compressors. The machine tool builders now assume that there is always a supply of compressed air

in the machine shop, and they design their tools with air actuated movements which increase their efficiency and speed of operation. The shop without the air supply and the manager who does not *think* compressed air is shut off from the use of these improved tools.

Compressors are now on the market with unlimited range of capacities, adapted to any mode of driving, entirely automatic and working with all possible economy of power. In urging their wider employment I must feel that I am aiming to promote the interest of the machine shop proprietor more than that of the compressor builder. From *Machinery;* with additions by the writer.



SKETCH OF COMPRESSED AIR AUTO STARTER.

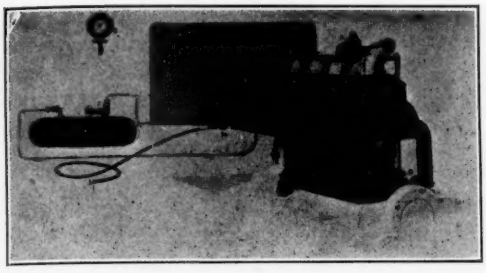
COMPRESSED AIR AUTOMOBILE STARTERS

It is a pleasure to us to speak of the renewal of youth which has come to the *Scientific American.* Although it is now in its sixty-eighth year we do not know any publication which is more completely up to date. Every issue is filled with live and valuable matter while its special issues once a month are notable for their excellence and completeness. From its recent automobile number we reproduce the following having to do with one of the most important of the later developments in automobile design.

The majority of leading motor car manufacturers have adopted automatic starters for their 1912 or 1913 models, and specialty companies are in the market with self-starters of half a dozen or more distinct types. Inasmuch as most of these are quite new and almost unknown to motorists in general, an attempt will be made to present briefly their different characteristics and methods of operation.

The reputation of one of the real pioneer automobile companies is staked on the success of the air pressure type and another company almost as old and with a very large annual output of cars has indicated equal confidence in the electric system.

In their main features the pneumatic startters are so much alike that one description will fit all except for minor constructional differences. The initial movement of the pistons necessary to create suction and compression in one or more of the cylinders is effected by the expansion of compressed air. This is admitted first to that cylinder in which the piston is on the explosion or working stroke. The pressure, which may be from 20 to 150 pounds or more per square inch, pushes this piston down, thereby causing the piston that is on the suction stroke to draw in a charge of fresh gas from the carbureter. At the end of the stroke the pressure is automatically transferred by means of a distributor or selector to the second piston ready for the working stroke, and as this descends it raises the one that was previously on the suction stroke and compresses the fresh charge, which is fired automatically by the regular ignition system when compression is completed. The engine is then ready to run on its own power, and the starter can be shut off. But if the engine fails to start on the first or second turn, the crankshaft can be revolved a large number of times before the air pressure is exhausted. With some systems the engine can be started 100 times, it is said, without renewing the pressure.

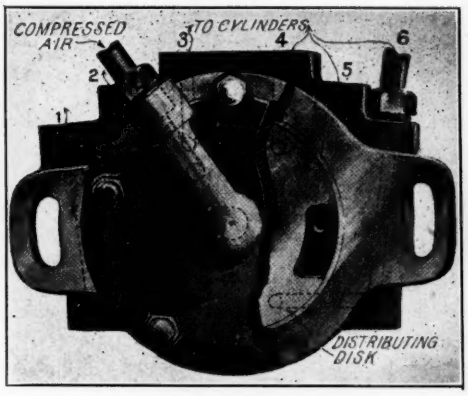


AIR RECEIVER AND CONNECTIONS.

Only the pressure of a foot button or push valve on the dash is needed to start the engine with this system; everything else is automatic. The shock of starting "on the spark" is avoided because, as in hand cranking, the reciprocating and rotating parts are set in motion gently by the air pressure before ignition of the first charge occurs. Operation is practically noiseless and, if the air passages are large, the action should be fast enough to insure ignition with a battery. One manufacturer asserts that the only time when it will fail to start an engine that is properly adjusted and in good running condition is when the crankshaft stops on a dead center. This does not occur often with the ordinary four-cylinder engine and cannot happen with six-cylinder engines.

The mechanism employed consists of a compressor driven by the engine, a pressure tank carried under the car, a pressure gage on the dash, a push valve on the dash or footboard, a distributor or selector driven by the engine, air valves opening into the combustion chambers of the cylinders and the necessary copper piping and brass unions to connect these elements in the proper way.

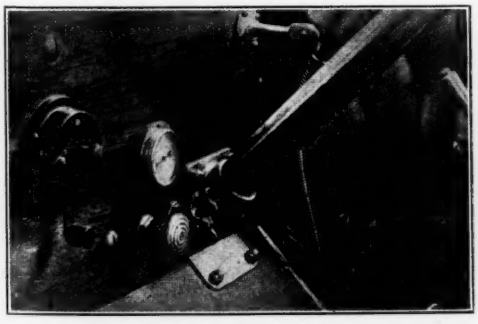
Usually the compressor is a small air-cooled



THE DISTRIBUTOR.

or water-cooled cylinder with a double piston so attached to the head of one of the engine cylinders that its lower barrel communicates with the combustion chamber while the upper barrel has a small valve opening to the atmosphere. When the engine is running, each explosion in that cylinder produces an impulse of the plunger in the compressor and causes the chamber communicating with the atmosphere to compress a small quantity of air and force it through a tube to the storage tank. From five to ten minutes suffices to fill the tank, and when a predetermined pressure has been attained—say 150 to 175 pounds—the back pressure automatically stops the operation of the compressor until the pressure has been reduced. The pressure is indicated at all times by the gage on the dash and should be maintained preferably at 60 pounds or more, although it is possible to start the engine with as little as 20 pounds.

When the push button in front of the driver is pressed to start the engine, it releases



REAR OF DASH.

ENGINE WITH COMPRESSOR AND VALVE.

some of the air from the tank and this passes to the distributor, whose function is to admit the air only to the cylinder that is on the working stroke, thus preventing the starter from working against compression. The device consists of a rotating metal disk or a sleeve having a slot that uncovers openings to tubes leading to the several cylinders in the order of their firing. It is geared to the cam shaft or magneto shaft so that it operates in perfect time with the engine. It runs continuously and necessarily stops, when the engine stops, in such position that the slot uncovers the opening that leads to that cylinder whose piston has last completed the compression stroke. As the crankshaft revolves under the pressure, the distributor uncovers the pipe to the next cylinder in order of firing and so on until ignition occurs and the engine begins to run on gas.

To prevent back pressure in the air pipes on the explosion strokes and consequent loss of power in the engine, a valve is introduced where each tube is connected to its cylinder. These valves are held closed normally by springs, but are all opened simultaneously by a buss bar or rod that connects them together and extends back to the push on the dash so that the same pressure that releases the air also opens the valves to admit it freely to the cylinders. The valves close automatically when the push is released.

Use of this system on a car obviates the necessity of providing a power tire pump for inflating tires or expending energy and patience over a foot pump. A flexible hose with a tire valve connection at its free end and a stop cock at the other end where connection is made, can be attached to the compressed air tank to be used for inflating tires, as is done by one of the motor car makers.

THE BRITISH OXYGEN INDUSTRY

A British oxygen company states that it has decided to erect an oxygen factory in Sheffield, where it is considered the growing demand for oxygen in connection with metal cutting warrants this extension. When the Sheffield plant is completed the company, which in 1908 had only three factories (London, Birmingham and Manchester), will possess eight factories in the United Kingdom, all situated in centers where the demand for oxygen is important—at London (Westminster and Greenwich), Birmingham, Cardiff, Manchester, Sheffield, Newcastle, and Glasgow. These extensions are entirely due to the demand for cheap oxygen in connection with oxy-acetylene welding and oxygen metal cutting. In view of the heavy freight charges on gas cylinders conveyed by rail, it is obvious that local sources of supply must tend to reduce the price of oxygen to the consumer. All the company's plants are of the modern liquid-air type, producing oxygen of a high degree of purity, and when the Sheffield plant is in operation their total output will be about 300,000 cubic feet a day. This supply is largely in excess of the present demand, but it is anticipated that this quantity may ultimately be required if the use of oxygen for metal cutting extends. The present average price of oxygen, supplied in cylinders, for industrial purposes is about £2 ($9.73) per 1,000 cubic feet, but reductions are expected if the demand increases.

EQUAL WORK IN TWO-STAGE AIR CYLINDERS

By J. William Jones.*

Until about ten years ago the average terminal gage air pressure required of an air compressor did not exceed seventy or eighty pounds per square inch; consequently single-stage compression was almost universally employed. The use of higher pressures in compresed air service brought about the employment of stage compression which has proved to be more economical and practical for all pressures exceeding seventy pounds per square inch. It is safe to state that about eighty to ninety per cent. of all the compressors sold in this country during the past five years have what is called compound or two-stage air cylinders. The majority of these were probably built for discharge pressures of about one hundred pounds per square inch, but there seems to be no uniformity among the users of compressed air as to what constitutes a standard pressure for a certain line of work.

The different purposes for which compressed air is utilized, naturally demand various discharge pressures. The constantly increasing application of compressed air to the numerous purposes for which it is adapted at the present day requires air pressures in two-stage

*Ingersoll-Rand Company, Painted Post, N. Y.

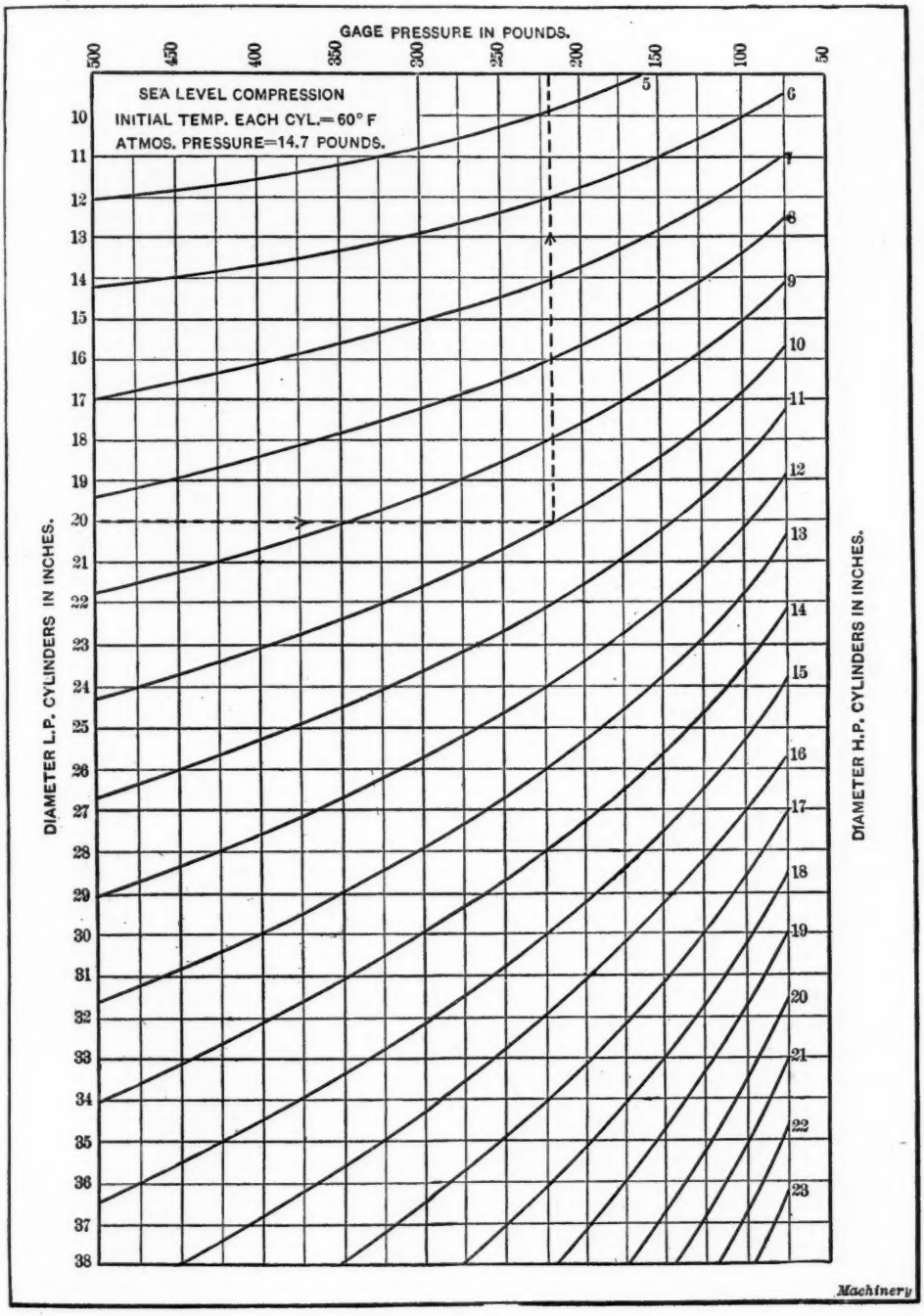

GAGE PRESSURE IN POUNDS.
500
450
400
350
300
250
200
150
100
50
SEA LEVEL COMPRESSION
INITIAL TEMP. EACH CYL.= 60° F
ATMOS. PRESSURE=14.7 POUNDS.
DIAMETER L.P. CYLINDERS IN INCHES.
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
DIAMETER H.P. CYLINDERS IN INCHES.
Machinery

FIG. 1.

machines varying all the way from seventy to five hundred pounds per square inch. Where one shop uses eighty pounds pressure per square inch for the operation of pneumatic tools it will be found that another uses ninety pounds, and still another one hundred pounds; one contractor will want to carry a line pressure of one hundred pounds for operating his rock drills and another will insist that he must carry one hundred and ten pounds. In the oil fields, for pumping oil, pressures ranging all the way from one hundred and fifty pounds up to five hundred pounds are required. New fields requiring higher pressures than those used heretofore for the ordinary lines of work for which compressed air has been the chief motive power are constantly presenting themselves.

In perusing the catalogues of the larger builders of compressed air machinery, it will be noted that they are now listing medium duty and high duty compressor sizes, the former having the cylinders proportioned correctly for pressures ranging from eighty to one hundred pounds and the latter for pressures ranging from one hundred to one hundred and twenty-five pounds. In addition to the above they carry a line of cylinder sizes which can be readily applied to the various compressor types for pressures ranging all the way from one hundred and fifty to five hundred pounds per square inch.

To know just what compound cylinder combination should be used for a specified terminal gage air pressure, requires some knowledge of the theory of air compression as well as a somewhat complicated arithmetical computation. The theory is not always easily remembered and errors are liable to occur in making lengthy computations. The accompanying diagrams solve the problems at a glance, requiring no knowledge of the theory of compression and no computations whatever.

Referring to Fig. I, the curves of which have been plotted for sea level conditions, let it be assumed that it is desired to know at what terminal gage air pressure the total work will be equally divided between two compound air cylinders of certain dimensions. Assuming that the compressor has a low pressure air cylinder twenty inches diameter and a high pressure cylinder ten inches diameter, the stroke being common to both cylinders, the low pressure cylinder diameter, twenty inches, will be found along the left-hand margin. Now projecting this point along the horizontal line in the direction shown by the arrow until the dotted line intersects with the curved line marked ten inches, and thence in a vertical direction until the upper margin is reached, the answer is found which in this case is two hundred twenty pounds per square inch; that is, an air compressor having a low pressure cylinder twenty inches diameter and a high pressure ten inches diameter with the stroke the same in both cylinders will have the total horsepower equally divided between the two cylinders when compressing to a final gage discharge pressure of two hundred twenty pounds per square inch, assuming the initial temperature to be the same in each cylinder which is equal to perfect intercooling between the two stages.

On the other hand, if it is desired to know what cylinder combination should be used for a specified terminal pressure, it is only necessary to first compute the diameter and stroke of the low pressure cylinder in relation to the desired piston displacement and then, starting at the upper border line at the required discharge pressure and at the left-hand border line at the correct low pressure cylinder diameter, note near what high pressure cylinder curve these two points cross when projected towards the curves. The above rules apply for any cylinder combination which the charts show and on any one of the three charts which have the curves plotted for sea level, five thousand and ten thousand feet altitude, respectively.

The formula for determining the final gage air pressure per square inch of any two-stage compressor in order to have the total horsepower required divided equally in each cylinder, is as follows:

$$P_3 = \left[\left(\frac{D^2}{d^2}\right)^2 \times P\right] - P$$

in which

P=atmospheric pressure in pounds per square inch.

P_3=terminal gage air pressure in pounds per square inch.

D=diameter of low pressure air cylinder in inches.

d=diameter of high pressure air cylinder in inches.

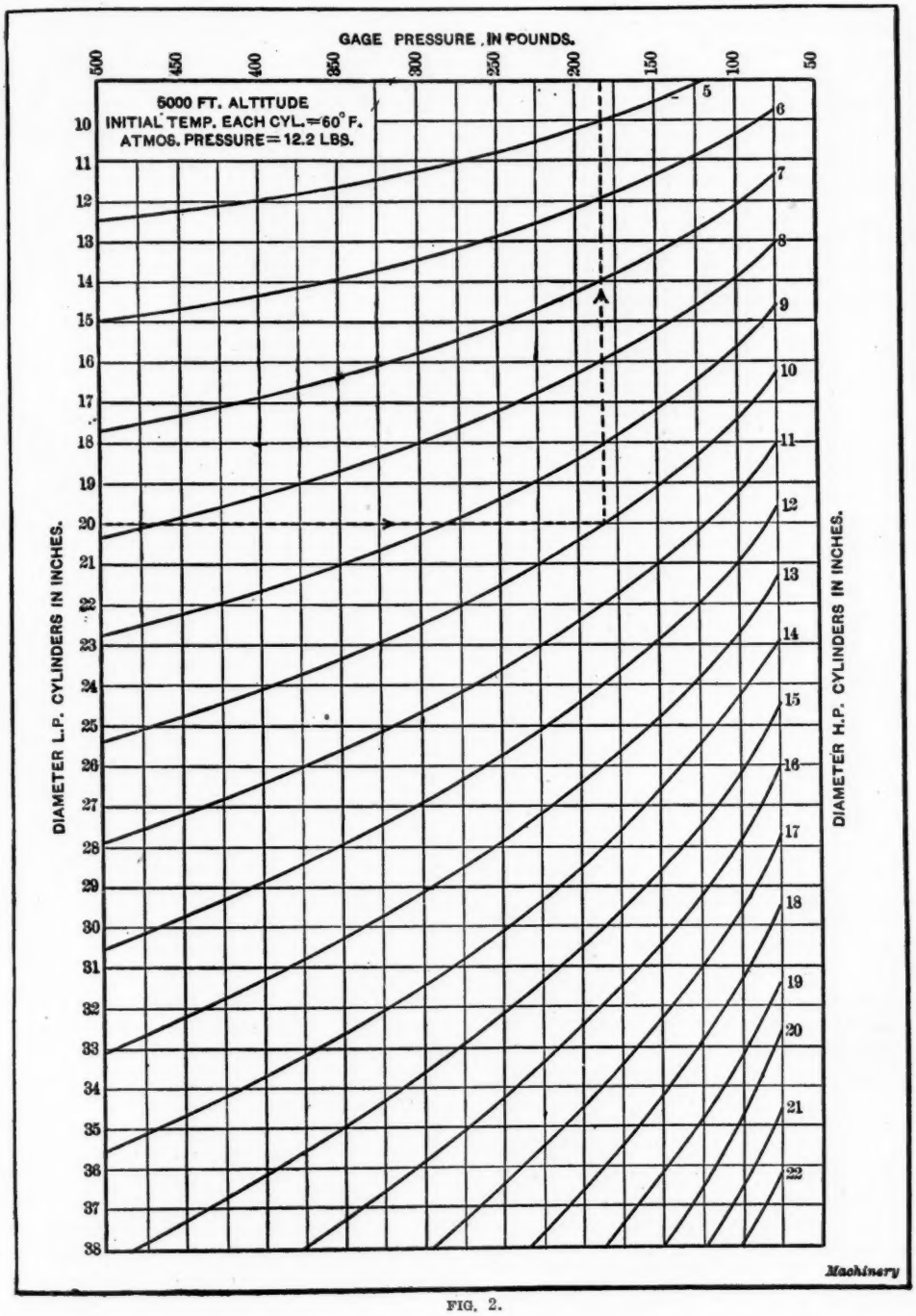

GAGE PRESSURE, IN POUNDS.
500
450
400
350
300
250
200
150
100
50
5000 FT. ALTITUDE
INITIAL TEMP. EACH CYL.=60° F.
ATMOS. PRESSURE=12.2 LBS.
DIAMETER L.P. CYLINDERS IN INCHES.
DIAMETER H.P. CYLINDERS IN INCHES.
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Machinery

FIG. 2.

Example: Having a low pressure cylinder 20 inches diameter and a high pressure cylinder 10 inches diameter, it is required to find the terminal gage air pressure per square inch (P_3) at which the work is equal in each cylinder at sea level; the atmospheric pressure being 14.7 pounds per square inch.

$$P_3 = \left[\left(\frac{20^2}{10^2}\right)^2 \times 14.7\right] - 14.7 = 220.5 \text{ pounds}$$

In the accompanying table are given the values of $\frac{D^2}{d^2}$ for various gage pressures from 75 to 500 pounds inclusive. This information is of value in computing cylinder sizes when the terminal gage air pressure is a settled fact. The diameter and stroke of the low pressure cylinder having been first determined relative to the required piston displacement, the diameter of the high pressure piston required to divide the load equally between the two cylinders is found by dividing the factor opposite the known gage discharge pressure into the area of the low pressure piston, to obtain the area of the high pressure. For 200 pounds final discharge pressure at 5000 feet altitude, the factor in the table is found to be 4.17. Assuming that a 25-inch diameter low pressure cylinder is required to give the necessary piston displacement, the area of the high pressure cylinder would be equal to the area of the low pressure, or 490.87 square inches, divided by 4.17 which gives a high pressure cylinder having an area of 117.6 square inches. This area is equal to a diameter of approximately 12¼ inches.

Gage Pressure, Pounds	Sea Level	5000 Feet	10,000 Feet	Gage Pressure, Pounds	Sea Level	5000 Feet	10,000 Feet
75	2.47	2.67	2.91	185	3.69	4.01	4.41
80	2.54	2.74	2.99	190	3.78	4.06	4.46
85	2.60	2.82	3.08	195	3.77	4.11	4.52
90	2.67	2.89	3.16	200	3.82	4.17	4.57
95	2.73	2.96	3.24	210	3.91	4.26	4.68
100	2.79	3.03	3.31	220	3.99	4.36	4.78
105	2.85	3.09	3.39	230	4.07	4.45	4.89
110	2.91	3.16	3.46	240	4.15	4.54	4.99
115	2.97	3.22	3.53	250	4.23	4.63	5.08
120	3.02	3.29	3.60	260	4.32	4.72	5.18
125	3.08	3.35	3.66	270	4.39	4.81	5.28
130	3.14	3.41	3.74	280	4.47	4.89	5.37
135	3.19	3.47	3.81	290	4.54	4.97	5.46
140	3.24	3.52	3.87	300	4.62	5.06	5.56
145	3.29	3.58	3.93	325	4.80	5.25	5.77
150	3.35	3.65	3.99	350	4.98	5.44	5.98
155	3.40	3.70	4.06	375	5.14	5.62	6.18
160	3.45	3.75	4.12	400	5.30	5.80	6.38
165	3.50	3.80	4.18	425	5.46	5.98	6.57
170	3.55	3.86	4.24	450	5.62	6.15	6.75
175	3.59	3.92	4.30	475	5.77	6.31	6.94
180	3.64	3.97	4.36	500	5.92	6.48	7.12

D = diameter low pressure air cylinder.
d = diameter high pressure air cylinder.
Atmospheric pressure at sea level = 14.7 pounds per square inch.
Atmospheric pressure at 5000 feet = 12.2 pounds per square inch.
Atmospheric pressure at 10,000 feet = 10.07 pounds per square inch.

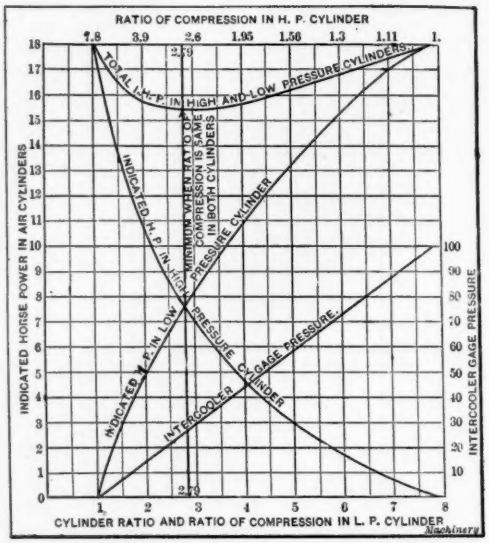


FIG. 4.

In theory the cylinders should be proportioned exactly in accordance with the above, all of which is based on the assumption that the intercooler reduces the temperature of the air to the original between the two stages. The intercoolers of the present day, however, can not be relied upon to do this, which means that, with the cylinders proportioned as above stated, the low pressure or intake cylinder would be required to do more than its share of the work due to the higher mean pressure in the cooler, on account of the thermal conditions not being perfect. It is, therefore, good practice to make the high pressure cylinder diameter a little in excess of the actual figures which the theoretical conditions show; that is, if the computation for the high pressure cylinder should result in a diameter of 9½ inches it would be good practice to call this diameter 10 inches.

Although the rules already mentioned are theoretically correct, it is possible to vary the proportions of the cylinders to some extent for any specified pressure without unbalancing the work to any appreciable amount. To show the actual relations between the horsepower, etc., in the two cylinders, the curves in the ac-

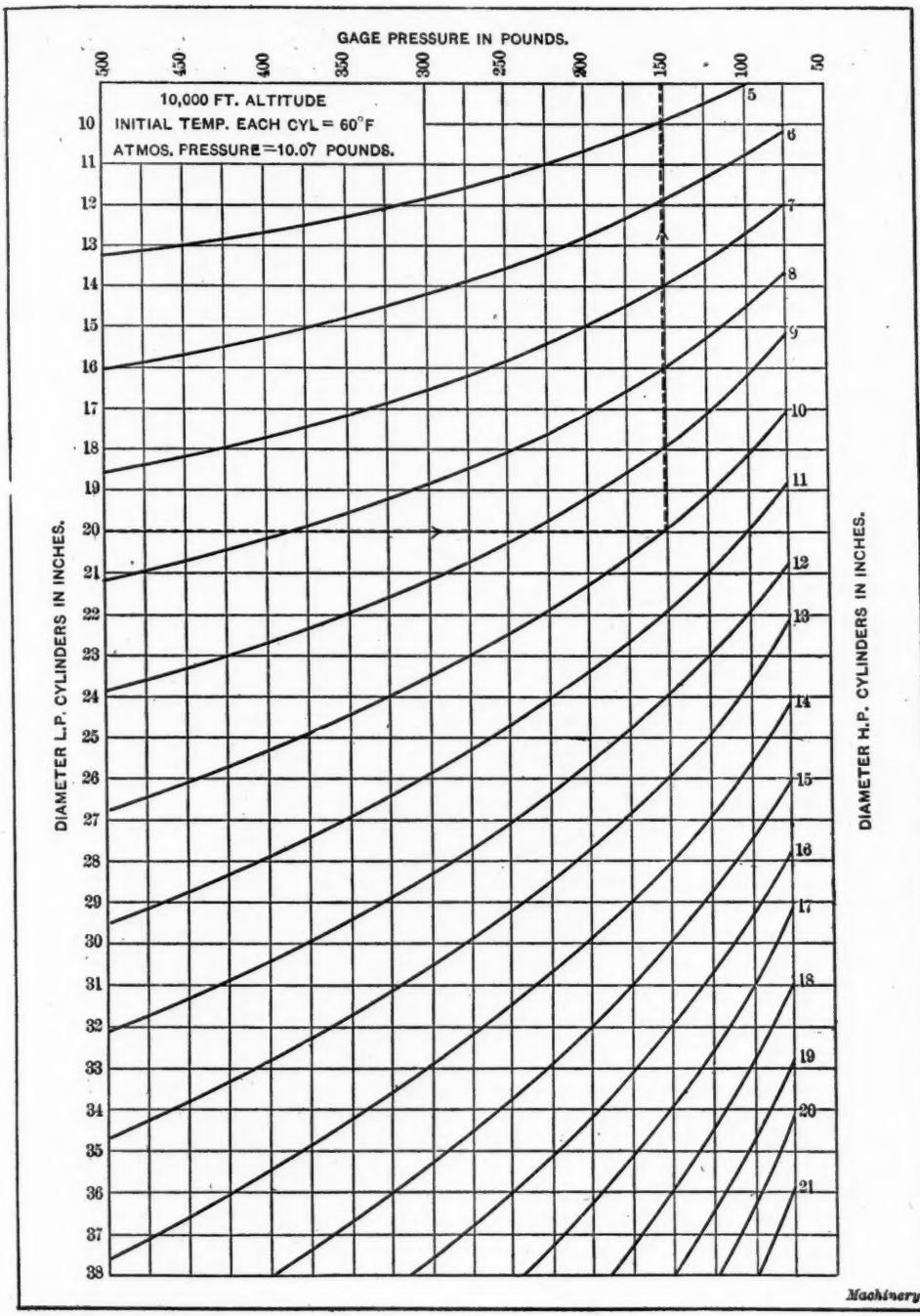

GAGE PRESSURE IN POUNDS.
500
450
400
350
300
250
200
150
100
50
10,000 FT. ALTITUDE
INITIAL TEMP. EACH CYL = 60°F
ATMOS. PRESSURE = 10.07 POUNDS.
DIAMETER L.P. CYLINDERS IN INCHES.
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
DIAMETER H.P. CYLINDERS IN INCHES.
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Machinery

FIG. 3.

companying chart Fig. 4, have been plotted. These curves show the theoretical horsepower required in either the high or low pressure cylinder when compressing to 100 pounds terminal gage pressure with different cylinder ratios. Also a curve for this pressure has been plotted showing the combined horsepower of the two cylinders with these different cylinder ratios. It will be noticed that the minimum horsepower is required when the ratio of compression is the same in both high and low pressures cylinders. In this case the ratio of compression should be 2.79, which requires 7.72 horsepower in each cylinder when compressing 100 cubic feet of free air per minute to 100 pounds gage pressure, or the minimum total of 15.44 horsepower in the two cylinders. This ratio of compression when the same in both cylinders, is also the theoretical ratio of cylinder volumes. The values $\frac{D^2}{d^2}$ already referred to in the accompanying table, are nothing more nor less than the correct cylinder ratios for the pressures listed and at the different altitudes specified in this table.

In observing the curve showing the total horsepower in the chart it will be noted that it is very flat at the point of minimum horsepower. This means that it is possible to vary the cylinder ratio to a greater or less degree than the theoretical conditions shown without affecting the total horsepower to any great degree. A safe figure would be about ten per cent above or below the theoretical, preferably below for the reasons already assigned to imperfect intercooling. A good rule for compressors delivering air at 100 pounds gage pressure is to make the area of the low pressure piston two and one-half times the area of the high pressure.

The intercooler pressure naturally varies according to the cylinder ratio; to show these pressures, a curve Fig. 4, for the different cylinder ratios has been included.

[The above we reprint from the issue of *Machinery* for January, 1912. The three large diagrams here reproduced belong to the valuable series of data sheets issued in connection with that publication.—Ed. C. A. M.]

One pint of gasoline will make two hundred cubic feet of air explosives when the gasoline is turned into vapor.

SUBAQUEOUS METHODS FOR DRIVING A LAND TUNNEL

Compressed-air methods have been in use for several months in driving through a soft, running material in a long section of the Big Savage tunnel on the new Western Maryland Railway extension between Cumberland, Md., and Connellsville, Pa. This tunnel is on the summit of the Allegheny Mountains, at an elevation of 2,350 ft. Construction was started on it about 15 months ago, the work being conducted from both portals in top headings in rock. The west heading had progressed about 640 ft. when on Dec. 19, 1910, a rapid inflow of soft, wet material blocked it and prevented further progress until an air lock was installed and pneumatic methods were introduced. These methods have coped with the situation successfully and the difficulty is practically past at the present time.

The tunnel is a single-track structure, 17 ft. in width in the clear, with a full semi-circular arch on a radius of 8 ft. 6 in., with the springing line 15 ft. 3 in. above subgrade. The length is 3,275 ft. The rock encountered in the first 600 ft. on the west and in all of the work on the east has been a hard gray sandstone, bedded in thick layers dipping toward the east at an inclination of about 2 to 1. It was originally intended to drive both headings through to a meeting before starting the bench, these headings being the full arch section above the spring line.

INRUSH OF SOFT MATERIAL.

Just previous to the time of encountering the soft material, the west heading was in rock so hard that practically a full shift was required to drill a round of holes. On Dec. 19, the holes were drilled and loaded as usual, but following the shot, soft mud and sand rushed in from the top and flooded the heading back to a point about 200 ft. from the face. This material was a mixture of fine water-bearing sand and finely-divided disintegrated rock, which was accompanied by so much water as to make it flow very easily.

It was at first thought that a soft pocket had been struck, so the heading was cleared as far as possible and work was resumed in the soft material, a pilot drift being driven at the crown to ascertain the conditions ahead. This drift required full box timbering and breast boards with straw packing, and pro-

gress was very laborious. The soft material ran into the heading practically as fast as it was removed, and the pressure from above became so great as to displace and break the drift timbering. As soon as a small amount of headway was gained with this drift, it was enlarged and timbered closely with wooden voussoirs. After continued efforts to advance in this way, which netted only about 15 ft. total gain in a period of more than a month, it became apparent that satisfactory progress could not be made by this procedure and pneumatic methods were determined upon. During this time the soft material and water continued to flow in and former springs on top of the mountain were observed to have ceased flowing. On Feb. 1, at a time when the frost was beginning to leave the ground, a large cave-in occurred in the ground surface over the tunnel, a hole about 20x20x16 ft. appearing, with soft wet material at its bottom. This was at an elevation about 200 ft. above tunnel subgrade.

COMPRESSED-AIR METHODS.

During the early part of February, an O'Rourke air lock which had been used on the North River tunnels in New York was brought to the site and installed in the heading, its end being set in a 4-ft. concrete bulkhead wall about 40 ft. in front of the point where the roof had broken through. This lock was 7 ft. in diameter and 25 ft. long, equipped with a material track and small steel material cars. Air pressure was put on the heading on Feb. 23 and work was resumed at the face, which was then 10 ft. behind its position when the first break occurred. A pressure of 20 to 35 lb. per square inch was found to be necessary, and an average of about 25 lb. per square inch has been maintained throughout the work.

A new tunnel section, enlarged to provide space for a concrete lining and invert, was adopted for the soft ground. This section, together with the timbering used in its construction, is shown in Fig. 1. The width of excavation for this section, upon resumption of work within the lock, was made 21 ft. between wall plates.

In proceeding with the excavation within the lock, a small crown drift was driven ahead as before and enlarged toward both sides by driving poling boards outward and working down with temporary radial timbering. The

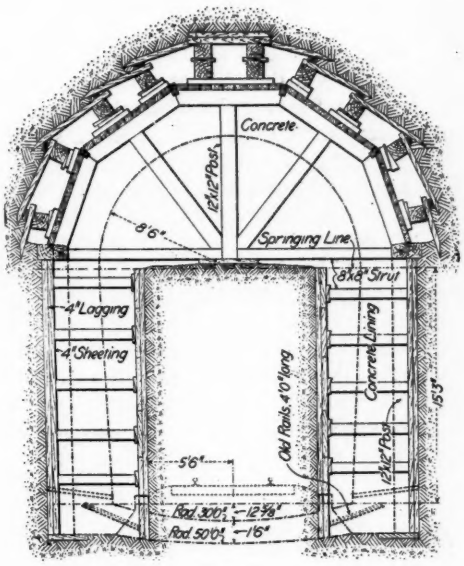


FIG. 1.

vertical posts in the sides of the drift were 12x12-in. timbers, 2 ft. on centers, so in widening toward the sides, excavation was made between the posts and the first set of temporary 12x12-in. radial struts placed in the space thus gained. The posts were then removed while the struts took the roof load, and then a second set of struts was placed in a similar manner. This was continued down far enough to permit placing one angle segment of permanent timber, and similar drifts were driven along the line and grade of the wall plates for setting the two lower angle segments and the wall plates. The segments consisted of 12x12-in. oak arch blocks, 2 ft. on centers with 4x8-in. oak lagging. Radial struts were provided to hold the blocks in place as the core was removed. All space behind the permanent timber was packed tightly and grout was forced in through pipes in the arch blocks by means of a compressed-air jet.

PLACING THE SIDE WALLS.

As the work progressed, the dip of the rock toward the east caused the hard rock floor of the heading to run out about 15 ft. beyond the first break, so that provision had to be made for the construction of the side walls below the wall-plate elevation to a footing on the solid rock. The method followed was to sink sheeted pits downward from the bench level along the lines of the wall plates, these pits

being worked back to the outside line of the excavation so as to permit the vertical side posts to be placed within them. The location of these pits and the plan of timbering them are shown in Fig. 2. The general procedure was to work them in 8x8-ft. sections, a set of 16-ft. timbering braced in the middle serving to form two such pockets. Tight 4-in. sheeting was used in sinking these pockets, the row next to the wall plates being driven on a batter so as to bring it eventually behind the lines of timbering. Pits of this size were as large as the material would permit, and in some cases the dimensions had to be reduced to even less than 8x8 ft. Considerable difficulty was experienced in gaining headway against the soft material in the bottom, and if the pressure was released, it would boil up rapidly.

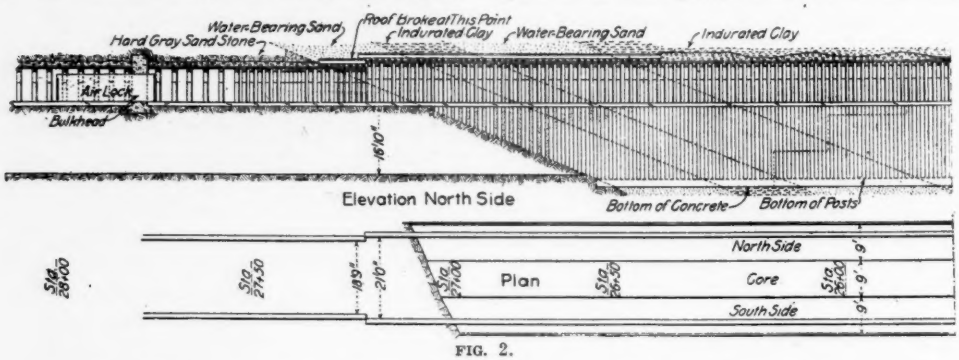


FIG. 2.

As soon as a short section of trench had been opened along one of the side walls, vertical 12x12-in. side posts were set under the wall plates, 2 ft. apart on centers, and the spaces between posts filled with a solid 12-in. wall of 1:3:6 concrete. This work was all behind the back lines of the finished tunnel side wall. When a section had been made tight on both sides in this manner, the tunnel core was removed as far down as the solid rock floor.

With the further advance of the working face, the floor continued to dip away and the depth of the pits and the length of the side-wall posts continued to increase correspondingly until, at a point about 40 ft. beyond the start of the soft material, the rock dipped entirely out of the bottom, placing the whole tunnel section in soft material. It then became necessary to place wall footings in the bottoms of the side trenches and to provide for the concrete invert. This involved the sinking of the pits to a level about 2 ft. below subgrade and placing a 2-ft. concrete footing about 6 ft. wide in sections 8 ft. in length, the walls being built as before. Concrete for all of the work within the lock was mixed by hand on a board inside.

DRAINAGE AND SPOIL HANDLING.

Drainage of the wet heading during these operations was effected by drawing the water to sumps in the ends of the side trenches and ejecting it by an air jet through a 4-in. pipe. equipped with a 3-in. wire-reinforced suction hose. A large amount of the soft material was also removed through this pipe with the water. The pipe discharged into a sump on top of the bench outside of the lock, where a force-pump threw the water to the outside drain and laborers shoveled the sediment into spoil cars. The gritty character of the material passing through the pipe caused very rapid wear, some of the valves and fittings lasting only a couple of days.

Outside of the air lock, material tracks ran along the top of the rock bench and then, at the point where work had been started by the steam shovel on the removal of the bench, a timber gallery was built at the springing line of the arch. The spoil cars ran along this gallery to a chute from which they dumped into 1½-yd. cars on the steam-shovel track below. An incline at the end of the gallery served to bring up the cement and other lock materials.

The labor problem for compressed-air work at this point in the mountains was a source of some difficulty. About 75 men for this class of work were required practically continuously, there being three shifts of about 25 men each. Most of the labor familiar with this class of work is found around the large cities, and the air men or "sand hogs" en-

gaged on this work came mostly from New York. About three-quarters of these were negroes. The nearest Southern States also supplied a few. During the times when the pressure was high, the working shifts were reduced to two 3-hour periods, with a 3-hour rest period in between.

POWER PLANT CHANGES.

A considerable addition to the power plant equipment was necessitated by the introduction of compressed-air methods. Originally there were two Class AA2 Ingersoll-Rand compressors, each giving 1250 cu. ft. of free air per minute. These were driven by three 100-hp. Brownell boilers. An additional compressor of the same type was installed, with capacity of 1650 cu. ft. of free air per minute, and two 125-hp. Pennsylvania boilers were added to the steam plant. This plant compressed the air to 110 lb. per square inch for all tunnel service, and that for the use in the lock was reduced to the required low pressure by a Westinghouse automatic reducer valve.

At the time these notes were made, hard rock had been reached again in the top of the heading and the inclination of the rock indicated that the entire section would again run into firm material. This is at a point about 195 ft. from that where the soft material first ran in. About 250 ft. still intervened between the west and the east headings. The latter has progressed favorably in hard rock of a character similar to that first encountered in the west heading.

On Oct. 25 the concrete lining was completed in all of the soft-ground section which was water-bearing, and from all indications it seemed safe to release the air and go ahead with ordinary soft-ground methods. This was done four days later, and for several hours there were no signs of undue pressure or of water breaking in, but in the evening of that day, the bottom of the tunnel bulged up ahead of the concrete invert and water came through in large quantities. Accordingly pressure was again applied so that a further advance of 50 or 60 ft. could be made before finally releasing the pressure.

Geological conditions somewhat similar to those in the tunnel have been found in a large cut about 1 mile farther west. This cut is 2400 ft. long, 90 ft. deep and contains about 250,000 cu. yd. It is at the summit point of the main Allegheny Mountain ridge, of which the ridge pierced by the tunnel is a spur. Wide seams of soft material between hard layers of rock were encountered in this cut and a large amount of water was present.

The Big Savage tunnel is being built for the Western Maryland Railway under the direction of Mr. H. R. Pratt, chief engineer, and Mr. G. H. Friend, principal assistant engineer. The Carter Construction Company, of New York, is the contractor. Mr. A. W. Jones, chief engineer of that company, is in charge of the work at Big Savage. Details of the compressed-air working methods were developed under his directions by Mr. E. E. Evans, superintendent at the tunnel.—*Engineering Record.*

MINES IN TWO STATES—OR IN NEITHER

Robert Richards, State Mine Inspector of Missouri, says that at Coal City, Mo., the entrance to the mine is in Missouri and the two cagers at the shaft bottom are in Missouri, but the main entry runs immediately into Iowa, and every other man working in the mine is working in Iowa. Consequently it was a question with him whether he had a right to inspect the workings of this mine and report to the Missouri authorities. At Leavenworth, Kan., another similar though opposite condition exists. The miners are all working under ground that is in Missouri, but the entrance to the mine is in Kansas and the cagers at the bottom are working in Kansas. In order to inspect this mine he had to go into the state of Kansas and come back into Missouri after reaching the bottom. He has asked advice as to whether one or both of these mines is in the state of Missouri—whether the Coal City mine is in Missouri or Iowa, and whether the Leavenworth mine is in Missouri or Kansas. If the Coal City mine is in Missouri and not in Iowa, then he thinks the Leavenworth mine is in Kansas and not in Missouri, since the conditions are reversed at the two mines. He is willing to inspect both of them, or either one, according as he finds his jurisdiction to embrace one or the other or both, but he is from Missouri and wants to be shown, so that he will make no mistake. He is required to inspect all mines in Missouri, but cannot legally inspect mines in another state—if either of them is to be considered as being in another state.

A TURBO DRIVEN CENTRIFUGAL BLOWER

We have the report of a test recently made of a centrifugal blower direct connected to a steam turbine, the test having been conducted with care and thoroughness as its purpose was to determine the fulfillment of certain guarantees given by the builders. The test was specially interesting from the fact that the air delivery pressure was about double that which has usually been considered the limit.

The blower set tested consisted of a double inlet Sturtevant multivane centrifugal blower mounted on the same bed with a Terry steam turbine and direct connected. It was to deliver 40,000 cubic feet of air per minute against a pressure of 40 inches of water, the test being to determine the water rate of the turbine and the closeness of the speed regulation as well as the volume and pressure of the air.

During the test, pressure, temperature and calorimeter measurements were made of the steam just in front of the governor valve, and the exhaust pressure was measured in the exhaust pipe just beyond the outlet of the turbine. The exhaust steam was taken to a surface condenser and the discharge water from the hot well was weighed. The condenser was vented at the top so that it would not produce vacuum at the exhaust of the turbine, which was run non-condensing.

To measure the volume of air discharged by the blower, a long tapered cone having a coefficient of discharge of 0.94 was attached to the outlet, the pressures being taken with a mercury U tube. The blower, rated to deliver 14,000 cu. ft. of air a minute, averaged 15,169 cu. ft. for nearly an hour. Steam required for the turbine was not to exceed 7,600 lb. an hour, but during this test steam was used at the rate of 6,587 lb. an hour, or 13.35 per cent. less than the guaranteed maximum.

Air pressure maintained was to be 40 in. of water, but for nearly an hour this blower averaged 47.3 in or over 1½ lb. per sq. in. It reached a maximum during a portion of the test of 51.7 in. Considering the excess in both volume of air and the pressure at which it was discharged, the blower set delivered 27.5 per cent. more work than was called for. Reducing the guaranteed conditions to steam consumption per air horsepower gave a result of 58.5 lb. as against the guarantee of 86.13 lb.

In the various tests the pressure at the nozzle inlets of the steam turbine varied from 100 to 106 lb. and the speed from 24.45 to 24.80 r.p.m. The velocity pressure varied from 46.2 to 51.7 in. of water, and the volume of air delivered from 15,000 to to 16,000 cu. ft. per minute, the air horsepower from 109.1 to 129. Average values for the test were: Steam pressure at the throttle, 145 lb. per sq. in., at the nozzle inlets, 102.5; pounds of steam used per hour, 65.87; speed, 2463 r.p.m.; velocity pressure, 47.3 in. of water; velocity of air at the outlet, 26,900 ft. per minute; volume of air delivered, 15,169 cu. ft. per minute. Actual air horsepower, 112.6.

A separate test to determine the speed variation gave the following results: The turbine was operated at 2,490 r.p.m. without load; with full load thrown on momentarily the speed was 2,400 r. p. m., and with the full load soon settled to 2,460 r.p.m. This shows that the momentary speed drop was 3.6 per cent. in the settled drop only 1.2 per cent. While the blower was running under full load at 2,460 r.p.m. the gate was closed suddenly the speed momentarily jumped to 2,575 r.p.m. or 4.7 per cent., but it quickly settled to 2,490 r.p.m., or an increase of 1.22 per cent. over that at full load.

WATER JETS IN ROCK DRILLING

Mr. C. J. N. Jordan, in the Journal of the South African Institute of Engineers, describes a method of dust prevention in rock drilling by forcing a jet of water at high pressure into the hole all the time the drill is working, showing at the same time a great increase in drill efficiency or an important saving of time and power.

The requirements of the water jet system are a line of pipes 1 in. or more in diameter, supplying water to within a safe distance of the face, where they cannot be damaged by blasting operations. To this is attached an armored garden hose of ½ in. or ¾ in. diameter. The hose is removed during blasting operations, but it is absolutely essential that it should reach easily up to the very face of the drive to insure proper working conditions for the system and also that there should be a head of water of 40 to 80 lbs. per square inch. From the very first stroke of the drill a back or dry hole gives dust; it is thus essential that so soon as the drilling operation starts a jet should be played on to the face where the

drill starts to collar. As the hole deepens, the hose, which has been previously slightly flattened, is inserted into the hole by the helper. The object of flattening the hose is dual—it assists in the formation of a more or less forcible jet and it does not interfere with the action of the drill, as it takes up less space in the hole.

It stands to reason then that this jet of water playing constantly to the very back of the hole kills the dust where it is made. It is found possible at any moment during the process of drilling to stop the machine and water at the same instant, and to detect that no dust and hardly any grit is present in the hole. The dust then is never formed. As the hole is deepened the hose may be inserted further, until it is about 18 ins. or 2 ft. in at the time the hole is finished. An examination of a finished 5 or 6 ft. back hole will show a clean barrel, free from obstruction of any sort. Once a hole is commenced with this method the water supply must not be interrupted, for the dust and grit would cake with the small amount of water left in the hole on stopping and jam the drill.

It may be thought that great inconvenience would be caused to the machine workers, or at any rate to the helper holding the hose in position, for one naturally thinks that a drill pounding away into a hole almost filled with water would cause spray and sludge to spurt all over the place. In practice this is not the case. The helper standing at the face all the time a hole is being put in will be found to be almost free from damp on his clothes, and as a matter of fact the water flows quietly out of the hole down the face carrying in suspension all the disintegrated rock, whether in the shape of dust or grit. The tendency of the drill to fitcher is minimized by this system, for the hole is kept so free from grit and the drilling is more rapid than under the ordinary system.

This method has to its credit advantages of economy, small in themselves, but nevertheless saving in time and money. We know that in practice it takes a miner anywhere from 2 hours and upwards to put in a back hole under present conditions. With the jet playing into the hole it is possible to put in a 5 to 6 ft. hole in about 1 hour and 20 to 30 minutes in hard quartzite.

The only practical objection to this method is the quantity of water used and the consequent flooding of the drive. The failure of similar ideas elsewhere has been due, probably to the small volume of water used. If, however, a drain is cut and kept open the water can be led away. The extra cost of pumping is inappreciable.

Below are given tables showing the records of two experiments in which it may be seen that considerable saving in time and in drill steel was made over the ordinary way of drilling a dry hole.

Holes 1 and 2 were 8 ins. apart and were drilled dry and wet respectively in hard quartzite, and in the same bed of quartzite. The same angle of elevation was kept by dropping the arm about 8ins. after the No. 1 hole was drilled. The same machine and men drilled both holes. The air pressure remained constant, 60 to 65 lbs. The collaring in each hole was good. The time given does not include time for changing bits, but only actual drilling time.

HOLE NO. 1—DRY.

	Minutes.	Depth, ins.	Bit marked
Collaring	4	0	A
Starter No. 2	10	5	B
Starter No. 3	27	7	C
Second cross bt	15	5½	D
Second chisel bit	10	6½	E
Second chisel bit	27	7	F
Total	93	31	

HOLE NO. 2—WET.

Starter No. 1 collared and drilled	9	11	G
Second chisel	7½	13	H
Third chisel	12	9½	J
Fourth chisel	14	25½	K
Total	42½	59	

HOLE NO. 3—DRY.

Collared and started hole	50	17	L
Second starter	25	6	M
Second cross-bit	28	7	N
Fourth chisel	18	7	O
Fifth chisel	29	11	P
Total	150	48	

HOLE NO. 4—WET.

Collar and starter	32	22	Q
Second diamond	41	28	R
Third chisel	14	18	S
Total	87	68	

The totals show 93 minutes to drill 31 ins., or .33 in. per minute, as compared with 42½ minutes to drill 59 ins., or 1.34 ins. per minute, by the method described. Furthermore the drills G, H, and J did 33½ ins., in 28½ minutes, as compared with 31 ins. in 93 minutes with 6 drills by the ordinary method. Holes 3 and 4 were drilled with two different machines in very hard quartzite cross cutting the formation. The two holes were in identical rock. The dry hole was steeper than the wet one.

Thus by the wet method 68 ins. were drilled in 87 minutes, or .78 in. per minute, as compared with 48 ins. in 150 minutes, or .33 in. per minute, by the dry method. The two drills Q and R drilled 50 ins. in 73 minutes, as compared with 48 ins. in 150 minutes with five drills. It will be seen therefore that there is a saving of from 30 to 50 per cent. in drills and that no more time is required for the drilling of a back hole than a wet or down hole.

VACUUM PPARATUS FOR CASTING METALS

BY E. F. LAKE.

While casting metals *in vacuo* is an old principle, it has not been developed to any extent until quite recently. Occluded gases and those segregated in large enough volumes to form miniature bubbles or the larger blowholes, are only beginning to be recognized as the real injurious elements in metals of all kinds. The oxygen, nitrogen and other elements that form these gases, enter into combination with the elements that are parts of the various alloys from which castings are made and form oxides, nitrides, etc., and thus detrimentally affect the strength, wearing qualities and other properties that it is desirous to obtain. By melting metals, or casting them in a vacuum, these gases can be almost entirely removed and the mechanical properties of metals or alloys greatly improved. This principle is fast growing in favor and therefore, it may not be very long before casting in a vacuum will be quite common.

Some metals are very brittle, and when worked by ordinary methods cannot be rolled and drawn. When melted in a vacuum, however, they have been drawn into wire for various purposes. Examples of such metals are tungsten and tantalum, which are made into wire for incandescent lamps. Another metal very difficult to melt in the open air is magnesium, and this has been readily melted in a vacuum furnace. This is accomplished by building an air-tight chamber around the melting pot or furnace and pumping out all of the air. An electric current then generates the heat necessary for melting the metal and no oxidation can take place, as the oxygen has been removed, likewise, the nitrides, sulphides, phosphides, etc., do not form and the metal has a more dense, homogeneous grain than can be given it by any other process.

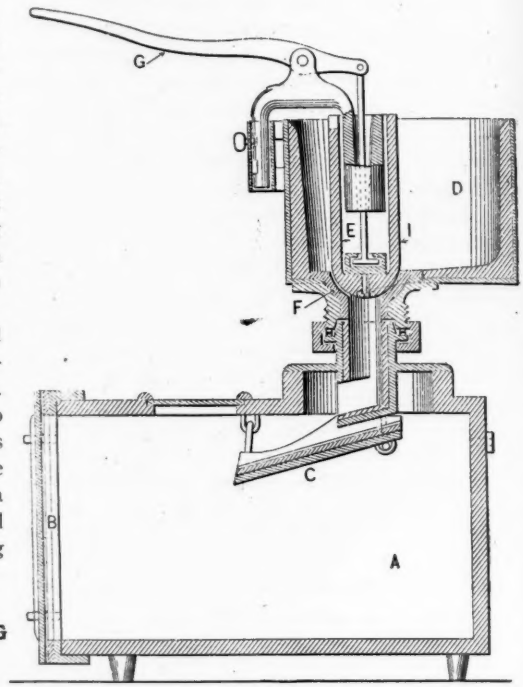


FIG. 1.

Even though the principle of casting *in vacuo* is very old in this country, the first recorded invention of apparatus for this purpose was that patented by H. V. Barnum, in 1879, as shown in Fig. 1. Here, A is the vacuum chamber, and B a door through which any kind of a mold can be inserted. This door covers the whole end of the vacuum chamber. A clay-lined pot, D, of molten metal is fastened to the top of the vacuum chamber in such a way that no air will be admitted and when the mold is ready to pour, valve E, which is made of some refractory material, is raised by lever G out of valve seat F, and this allows the molten metal to flow from pot D through spout C and into the mold. Spout C is made fan-shaped so the vacuum may cause the es-

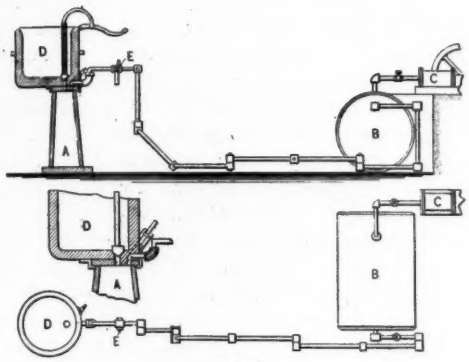


FIG. 2.

cape of most of the gases out of the molten metal as it flows over the surface.

CASTING STEEL INGOTS IN A VACUUM.

In Fig. 2 is shown an American device for casting ingots *in vacuo*. In this the ingot mold and ladle are constructed in such a way that when the ladle of molten metal is placed on top of the ingot mold, it seals it air-tight. To remove the air from ingot mold A, a tank much larger than the mold is located at B and vacuum pump C brings about a vacuum in tank B. Ingot mold A is connected by piping to tank B and when the ladle of molten metal D is lowered to the top of the ingot, ready to pour, valve E is turned on and into tank B is exhausted the air in the interior of ingot mold A. The vacuum pump is kept working all the time the ingot mold is being filled. Thus, while the molten metal is falling into the mold and flowing around to different parts, the gases are carried away. With this arrangement a universal joint makes it easy to connect to each ingot mold in a short time, and thus very little time is lost.

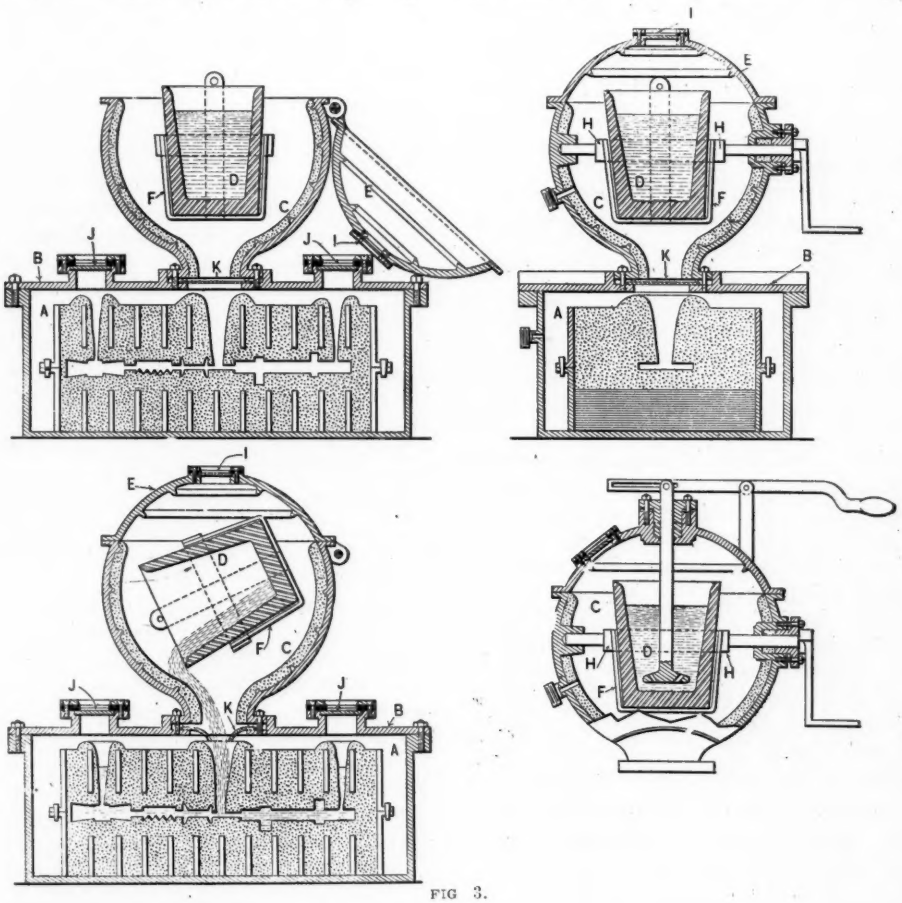


FIG 3.

CASTING SAND MOLDS IN A VACUUM.

Another apparatus for casting sand molds *in vacuo* was brought out in 1893; its construction and method of operating is shown in Fig. 3. In this, A is the vacuum chamber; B, the top which lifts off to admit the mold; C, the ladle container, which is also a vacuum chamber, and D, the ladle. To operate it, cover E is swung back, as shown in the upper left hand view, while the ladle of molten metal is lowered into its holder F. The cover E is then swung over the top and it fits air-tight, as shown in the other views. When the air has been exhausted from chambers A and C, ladle D is turned over in its trunnions H H, and pours the molten metal into the mold. In the ladle cover at I and in the top of the mold chamber at J J, are located glass plates so that the operator can see how the ladle is working and when the mold is filled.

While exhausting the air from vacuum chambers A and C, the gases and vapors rising from the molten metal are carried away and this renders the metal dead by removing all tendencies toward ebullition. By removing the gases from the metal, a more dense and fine grain is given the castings and as the molecules that form the mass are not separated by these gases they are held together with a great cohesive force.

If desired, an attachment can be easily put on cover E by which the metal in mold may be stirred by a disk, located on the end of a bar passing through the center of the cover and attached to a lever on the outside. Such an arrangement is shown in the lower right hand view of Fig. 3. It would hasten the pouring, as the ladle is turned over as soon as the gases cease to rise from the molten metal. Stirring would bring all parts of the molten metal subject to the vacuum condition, and thus quicken the escape of the gases. To facilitate this, a fusible plate is located at K to separate the ladle chamber from the mold chamber. Thus, the air can be exhausted from each separately and the gases drawn away from the ladle without interfering with the mold. As soon as the molten metal strikes this plate it melts and allows the metal to flow through, as shown in the lower left hand view.

APPLICATION OF VACUUM TO DIE CASTING.

The most successful and largest application of the principle of casting in vacuum is in connection with die-casting. As permanent molds that are made of metal are used to give the castings their shape, a vacuum can be established in their cavity without using a vacuum chamber, or the die-mold can be located inside of a vacuum chamber without specially constructing the mold, fear of injuring it, or altering its ability to make perfect casting. They can be made to operate automatically either inside or outside of a vacuum chamber and very little additional apparatus is required on the die-casting machines. The vacuum overcomes faults that it is very difficult to get rid of in any other way when squirting molten metal into metal molds under pressure.

To establish a condition of vacuum when manufacturing die-castings, several forms of machines attach piping directly to the casting cavity in the die-molds and connect this piping to an air pump. This removes the air from the mold just before squirting in the molten metal. This insures that every corner and crevice in the die-mold is completely filled with molten metal and good sharp castings with perfect exteriors are obtained.

A die-casting machine that uses this principle is shown in Fig. 4. In the upper view, die-mold A, which is in three parts, is connected by flexible hose B to air-pump C. In this position, the die mold is ready to receive the molten metal that forms the casting. In the lower view, the mold is shown as it is opened for the ejection of the casting. As will be seen, the outer half of the mold is located on a carriage that rocks away from the inner half of the mold; while the upper part of the inner half is raised away from the lower part. This machine is driven by pulley and belt and all of its movements are performed automatically by the aid of gears and cams. All the attendant has to do, therefore, is to keep the melting pot filled and carry away the castings.

While the extraction of the air from the die-mold, as shown in Fig. 4, has many good features, it is not possible to extract any of the gases that may be contained in the molten metal. In order to obtain a more complete vacuum, therefore, a die-casting machine like the vertical one shown in Fig. 5, was designed and this is in daily use. Here, a comparatively large vacuum chamber, A, forms the body of the machine and the melting pot D, with its gas-heating furnace C, is located over

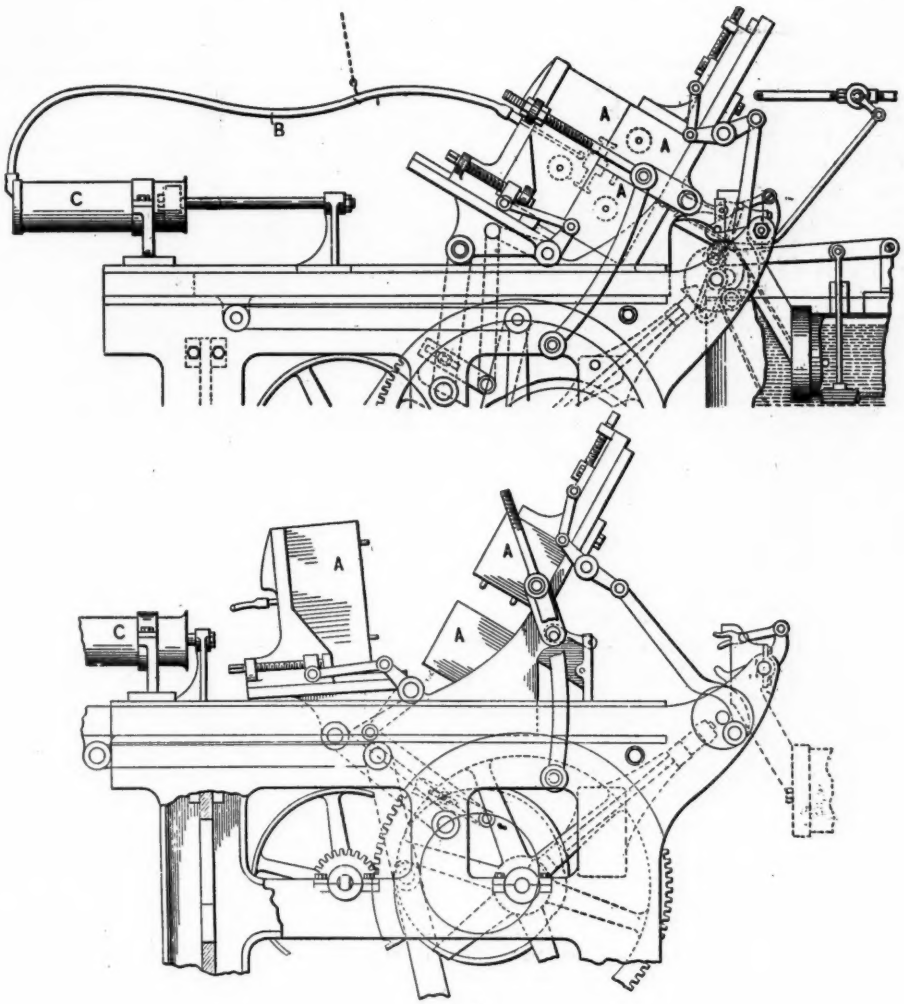


FIG. 4.

it in a very similar manner to that of the sand mold casting apparatus shown in Fig 1. In this case the driving shaft B, with its pulley R, and the cams that control the movements of the machine, are located in the base, below the vacuum chamber.

The die-mold E is located just below the melting pot and inside vacuum chamber A. To make such a machine successful, therefore, the mold must be opened and closed; the molten metal squirted in, and the casting ejected from the mold automatically, and that is the manner in which this machine operates. The mold opening and closing automatically, inside of this vacuum chamber, no air is allowed to collect in the casting cavity, even when the mold is opened to eject the casting. Any gases that may be in the metal when entering the die-mold, are inclined to be drawn through the vent openings of the mold and out into the vacuum chamber. A more complete vacuum can thus be obtained than with the principle shown in Fig. 4.

By placing the die-mold inside a vacuum chamber, as in Fig. 5, these troubles are overcome as a continuous vacuum can be maintained in this chamber. By milling out sections, one or two thousandths of an inch deep, on the parting surfaces of the mold, the mold will be vented, so a continuous vacuum can

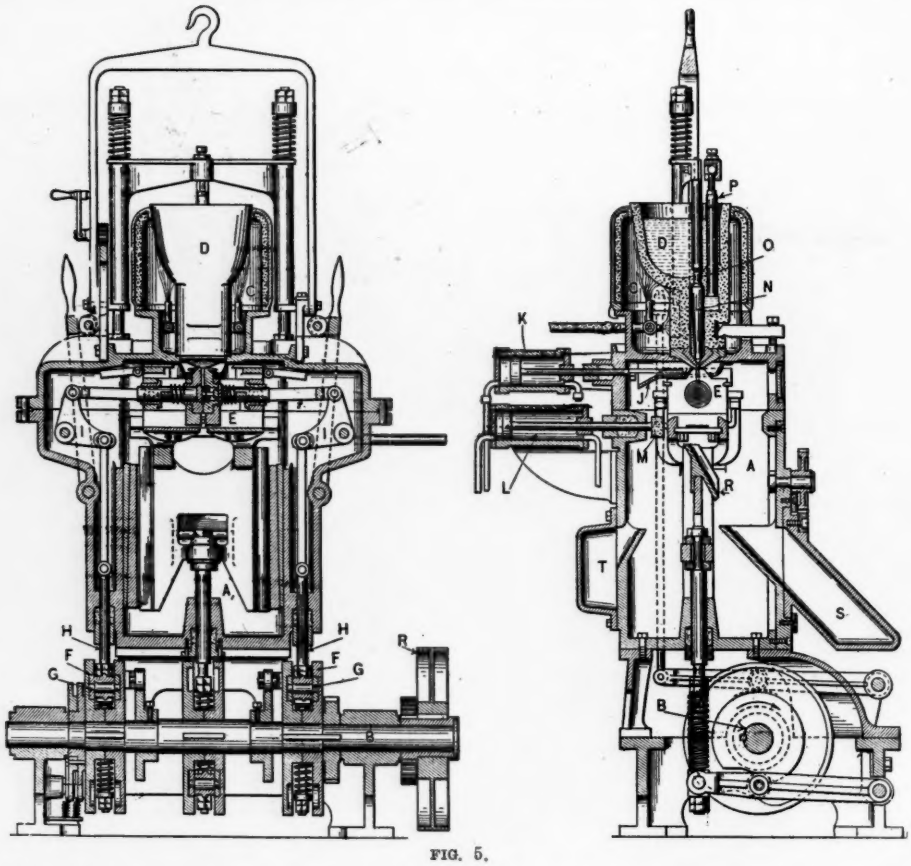


FIG. 5.

be maintained in its casting cavity. The mold is then easily parted and these vent openings are not large enough to fill with metal and form fins on the castings. In addition to causing the metal to be drawn into all crevices of the mold the molten metal is forced into the mold with from 80 to 100 lb. per square inch pressure. This tends still further to refine the grain of the castings.

In the left hand view of Fig. 5, the mold is shown closed; but when the double cams F turn over, rollers G on rods H operate levers I and thus pull the halves of the die-mold apart. As there is always a tendency of molten metal dripping when the die-mold is pulled away, or parted, a drip deflector J is immediately pushed under the nozzle and causes any drippings to fall into pocket T. This prevents molten metal from spoiling the finished castings. A second air cylinder L moves Brush M over to brush out the casting cavity in the die-mold. To force the metal into the mold when it is closed, valve N is pulled away from its seat in the nozzle opening and this closes another seat above it at O, where the metal enters the passage from the melting pot. When opening O is closed, plunger P is forced down and this squirts the metal, contained in the passage, into the die-mold.

All of these motions are timed so that the various operations will follow each other continuously and produce castings without any manual labor except that of filling the melting pot. They are turned out by this vacuum machine much faster than they can be made by any hand-operated machine. In fact, as fast as the metal will solidify in the mold, the casting is thrown out and the mold closed for another without any lost time. As the mold is opened and the castings are ejected, they fall into deflector spout R, which throws them into pocket S, and they are then easily taken away from the machine. This is doubtless the most perfect manner in which castings of any kind

are made, and it shows the height of the development of the die-casting process and the perfection that has been reached in casting methods.

A horizontal machine of this same type, fastens one half of the die-mold to the nozzle and locates the other half on a carriage that slides back and forth. Thus, the back half is drawn away from the forward half to eject the casting, the vacuum is established by two tanks, in which a continuous vacuum is maintained, located on each side of the mold. When the half mold moves to the closed position, connections are made to these vacuum tanks and the air is sucked out of the cavity of the die-mold. The exact form of the machine is immaterial as long as the vacuum is successfully created in the casting machine.

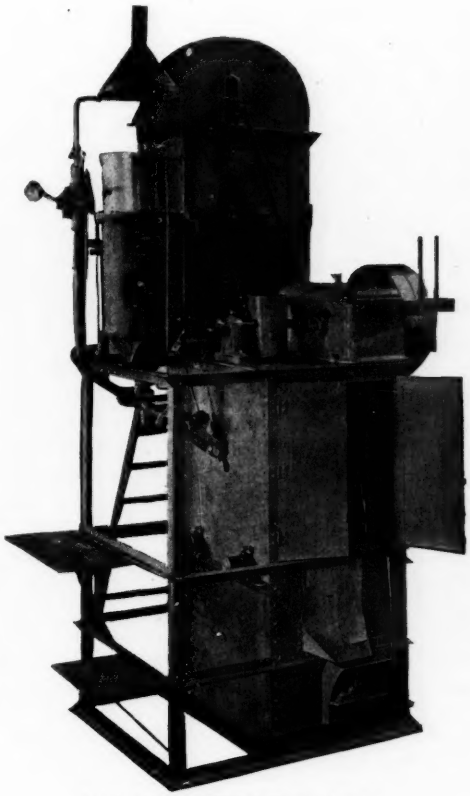
The thing that has made it possible to manufacture die-castings of the strength of yellow brass is the application of the vacuum principle to die-casting machines. To construct a die-casting machine and molds that will stand a high enough pressure on the incoming metals to make dense, sound and strong castings would be very expensive, but by adapting the vacuum principle to these machines, this has been accomplished at a cost that is not prohibitive.

All kinds of castings are made so much better by casting them *in vacuo,* as well as by melting the metals in a vacuum, that this principle is bound to increase in commercial use and doubtless vacuum castings will become more commonly made and used in the future. Improvements will probably be made in the methods of casting sand molds in a vacuum that will make these cheap enough to be a commercial success, and where any kind of a permanent mold can be used, castings for machine parts or for various kinds of apparatus and instruments can be profitably made in a vacuum.—Abstract from *Iron Age.*

A SELF-CONTAINED SAND-BLAST TUMBLING MACHINE

The half-tone shows a combined sand blasting and tumbling apparatus brought out by the London Emery Works Company, of Park, Tottenham, London, N.

The outer case of the machine encloses a perforated tumbling barrel rotating on rollers. On the inside of the barrel a number of pieces of angle iron are fixed which throw the castings in different directions and thus prevent any of them from simply slipping around the inside and escaping the sand blasting. As the barrel turns quite slowly not much tumbling effect is apparently expected. According to the size of the barrel, blast nozzles are placed in an inclined direction and are given a swinging movement so that they thoroughly blast the entire contents. The opening provided in the barrel for charging the castings is also used for changing the chilled iron nozzles which are held in position by a union.



SAND BLAST TUMBLING MACHINE.

Under the barrel an inclined perforated plate is fixed on to which the castings fall as discharged. Beneath the plate is a spiral conveyor which carries the used sand to a bucket elevator. The driving arrangements for the barrel and the nozzles are on the top of the outer casings in a closed cast iron box. The largest size of this apparatus is fitted with two conveyors and double elevators to deliver the sand into the two-pressure sand blast apparatus placed on each side of the barrel. The

sand or shot falling out of the barrel with the castings drops through the perforations of the slide. While the barrel is being discharged and reloaded the two-pressure sand blast apparatus is refilled with sand or shot. What is not reduced to dust falls through the perforations of the barrel and the outlet shoot into the spiral conveyor and thence by the elevator it is returned to the two-pressure sand blast apparatus, while that which is reduced to dust is carried away by an exhaust fan.

Previous designs of apparatus of this type have had the disadvantage of great wear of the piping between the sand blast apparatus and the tumbling barrel, and there has been an inefficiency of the sand stream on account of the many alterations of direction by the various sharp bends traversed before reaching the nozzles.

By attaching the sand blast apparatus to the side of the outer casing this machine is made self-contained, which not only saves the intermediate rubber hose but also reduces the floor space. This construction also allows all the valves to be conveniently placed, and there is less time lost in filling, starting and stopping, and cleaning the valves should they become choked.

VISIONARY TAYLORISM

The following occurs in the London *Engineer's* review of the new book, *Power,* by Dr. Chas. E. Lucke, lately noticed in our columns:

But having discussed the forces causing unrest in the labour world he propounds his remedy. It is somewhat of an anti-climax to find that this remedy is an application of some form of profit sharing, and of what has come to be called "motion-study." The first of these remedies whether of the nature of real profit sharing or of the premium bonus type, has already been proved of no avail, and even a source of further discord. The second, popularly known as "Taylorism," is just beginning to rear its head in America. We have already expressed our opinion on this inhuman method of speeding up and reducing labour wastage, and need only add one word to what we have already said against the system. It is undoubted that there is an enormous waste of labour every day in our workshops, and that if this labour were usefully applied the cost of production might be greatly lessened, and wages consequently greatly increased. But Mr. Taylor and Dr. Lucke, and all others looking with covetous eyes at the labourer's idle movements, must know that no machine, however perfect mechanically, can possibly convert into work all the energy supplied to it. A large part is wasted, and must be wasted, in accordance with natural law. Can the advocates of Taylorism or any one else expect the human machine to be more perfect?

BILL AND THE SUPE

Now listen to me, while I tells to you,
The tale of the Supe an' Bill McGrue.

Bill he was takin' a little mope
After drillin' his holes in the stuffy stope.

An' settin' down on a timber car
He lights a match to a bum cigar.

He scurcely more than gits a light
When a guy in overalls heaves in sight.

"Takin' a rest?" says he to Bill.
"You bet," says William, an' sets right still.

"Ain't you got nothin' at all to do?"
"I have," says Bill, "when I'm ready to."

"What would you do," says the stranger guy,
"If the shift boss happened to wander by?"

"I'd set," says Bill, "like a tired bloke,
An' take my time fer my rest an' smoke."

"Do you know," says the stranger, "who I am?"
"I don't," says William, "nor care a damn!"

"Well, I am the Superintendent here!"
Bill's grin extended from ear to ear.

"The Supe," he says, "of the hull big mine?
That's bully," he says, "that's grand, that's fine;

A mighty good job fer a man to git,
If I was you I would tend to it!"

Then Bill leans back on the empty car
An' goes on smokin' his bum cigar.

Berton Braley in *N. Y. Times.*

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Established 1896

W. L. SAUNDERS, - - - - Editor
FRANK RICHARDS, - Managing Editor
F. C. IGLEHART, Jr., - Business Manager
W. C. LAROS, - - Circulation Manager

PUBLISHED BY THE

Compressed Air Magazine Company
Easton, Pa.

New York Office—Bowling Green Building.
London Office—165 Queen Victoria Street.

Subscription, including postage, United States and Mexico, $1.00 a year. Canada and abroad, $1.50 a year. Single copies, 10 cents.
Those who fail to receive papers promptly will please notify us at once.
Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

Entered as second-class matter at the Easton, Pa., Post Office.

Vol. XVII. FEBRUARY, 1912. No. 2

CONTENTS

Machine Shop Without Compressed Air. 6315
Compressed Air Automobile Starters.... 6316
British Oxygen Industry..... 6318
Equal Work in Two-Stage Air Cylinders 6318
Subaqueous Methods for Sand Tunnel.. 6324
Mines in Two States..... 6327
Turbo Driven Centrifugal Blower..... 6328
Water Jets in Rock Drilling..... 6328
Vacuum Apparatus for Casting Metals.. 6330
Self-Contained Sand-Blast Tumbling Machine 6335
Visionary Taylorism 6336
Bill and the Supe..... 6336
Air Engineering 6337
Rock Drill Appreciation..... 6338
Progress on the Great New Zealand Tunnel 6339
Grouting Leaks in the Washington Street Tunnel under the Chicago River.... 6339
Later Refrigeration Methods for Dry Air Blast 6340
Use of Oxygen Helmet in High Temperatures 6342
Notes 6343
Patents 6344

AIR ENGINEERING.

Why have we not air engineers as well as electric engineers and the others? Compressed air and the air compressor would seem to be sure of constant and of continually extending employment, as long as industry and civilization continue. The conditions of air employment already have almost unlimited range. Air is required, according to the uses to which it is to be put, at all pressures, from that which is measured by tenths of an inch of water, up to thousands of pounds to the square inch; and in all quantities or volumes from that sufficient to spray perfumery upon a lady's handkerchief up to the blowing of a blast furnace.

The requirements in air compressing apparatus have, by a large industrial automatism, differentiated or separated themselves until now we have immense manufacturing establishments devoted each exclusively to one of at least four different and distinct classes of air compressing apparatus. There are manufacturers of fan blowers, of "pressure" blowers, of blowing engines, and of air compressors distinctively so called, each producing its specialty exclusively.

By far the most numerous and, as would seem, the most important of these several apparatus, is the air compressor, whatever the drive of it may be, which has air compressing cylinders with reciprocating pistons, so that compressors of this type must apparently, for a long time to come, have the first place in our considerations of efficiency and of applicability to the different requirements which are developed.

Although the operating of a water pump and of an air compressor may, at first thought, seem quite similar, the conditions and requirements really are different all the way through, and the problem of the latter is vastly more complex and difficult. The elasticity alone of the air changes the character of the work at the beginning of it, and the resulting transfers or transformations of opposing pressures are only a small part of it. Questions of temperature, of humidity, of velocities of flow, each furnish their factors, and then the matter of storage and of adjusting the air output to the consumption demand to be provided for.

It is no longer sufficient in any line of manufacture to produce a machine which will actually work and which can be guaranteed to

keep on working, although these are essential requirements. The precise manner and measure of its working in addition to that may determine its acceptance or rejection. The working must be as economical of power as possible, or must best satisfy certain other conditions of service which are often quite imperative. The fewer the sacrifices of essentials involved and the more satisfying the unavoidable complications, the more desirable the apparatus.

In the variety of air compressors required, both as to size or actual capacity and also as to the relative capacities of the power-developing and the power-applying elements, it must be evident that the works of large capacity has a great advantage, and one which it may legitimately claim for itself.

Not only is the most satisfactory air compressor to be expectantly sought in the older and larger establishments, but here also should be found the larger experience, and, as a consequence, the most competent advice as to air employment. One cannot be a qualified designer and builder of an air compressor, or of anything else, without following it out into the field of its employment to see how it does its work and how its working might be improved, or, in some cases, how changes in the methods of using the air might be made for mutual advantage, so that in this way the compressor man may be a desirable adviser for the rock drill man, the pneumatic tool man, the tunnel-driver, and the other air workers.

ROCK DRILL APPRECIATION

The beneficient reach of the rock drill is comparable in extent with that of the steam engine itself, although its fame is much less noised abroad. As a striking generalization it may be said that much less than one per cent of the inhabitants of the earth have ever seen a rock drill, and perhaps not more than one per cent. of those who have actually seen a rock drill have come into intimate relations with it, while, on the other hand, perhaps not more than one per cent. of all who live on the earth have not had their lives affected, and generally betted, by this active agency though to them unknown.

This of course it is not possible to prove, but it still is easily credible. Not all are civilized, but where is the savage whom civilization has not touched, and whose habits and whose modes and means of living have not been affected? Then we have only to remember the status of the rock drill in the van of civilization and our opening assertion proves itself.

In the middle of the last century the rock drill began its lifework as the driver of tunnels, and in a short time it became the most facile instrument in all rock cutting, not only in tunnels and mines perforce, but for all exposed work as well, so that it now has a foremost place in engineering operations, the primary and ultimate purpose of all of which seems to be the facilitating of communication and the hastening of the transfers of our products and acquisitions.

While the rock drill works directly in preparing the way for the locomotive and its train, it indirectly does as much for water traffic also. It cuts canals through rock, does subaqueous work to deepen or widen or straighten ship channels and gets out the stone for piers and docks. All the materials of the steamship, and the coal that drives it, are got by the rock drill, and members of the rock drill family rivet the plates and frames together. Then the cargo which the steamer carries all in one way or another has been touched by the rock drill, and much of it may be said to be exclusively of rock drill creation, as for instance the teeming products of the once arid plains which now have been irrigated through the rock cut waterways, these rich fruits and other good gifts of the soil going to gladden all the earth.

This is no summary of the work of the rock drill but only a hint as to one portion of it. The rock drill needs no advocate or promoter. It pushes its way through the world as its bit pierces the rock. Its work grows before it, and the more it does the more there is for it to do, and especially the greater is the variety of its task, to which it is continually adapting itself by sending out new members of its family with new and special qualifications.

While all in the world reap benefits from the rock drill, and while many when told of its work may attain to some appreciation of its beneficence, only those most intimately in touch with it can really know the measure of it as a product of multifarious and untiring ingenuity in the design, of marvelous skill and precision and care in the manufacture, and of

largeness of enterprise in the commercial handling of it. The manufacture of the rock drill, and of all which the name covers, with that of the air compressor which gives it life is one of the world's great industries, which no small and no unexperienced organization can be expected to competently handle. The speed and inertia of the latest steamship is typical of that of the modern manufacturing establishment, and the size of either is a function of success.

PROGRESS ON THE GREAT NEW ZEALAND TUNNEL

Our readers have been reminded from time to time of the Otira tunnel, 5⅓ miles long, which is being driven through the "Southern Alps." Our latest news concerning it comes from Vice Consul Henry D. Baker in *Consular and Trade Reports*. He says:

I recently witnessed construction work at this tunnel, which it is estimated will cost over $3,500,000. There is a grade in this tunnel of 1 foot in every 33 feet upward from the west coast side, which makes it difficult to keep water out of the eastern end, even with much pumping, so that work at this end must necessarily be much slower than at the other end, where the water will easily drain out. From the western side at Otira, in company with the engineer for the work, I went 1½ miles into this tunnel—as far as completed. We were taken in on a train of trucks loaded with concrete, drawn by an American electric locmotive fed with current from an overhead wire. During the last quarter of a mile, where there was considerable work going on and the passage is only partially excavated, it is unduly dangerous to have live wires in the tunnel, so use is made of an ingenious contrivance of an insulated cable wound up on the locomotive, which is made to connect with the trolley wire, and spins out as the locomotive goes on its course, the current being received through this cable and applied to the locomotive, so it continues its uphill course through the tunnel without life being endangered. This interesting locomotive is much used, I understand, in tunnel work and mining operations in the United States, where the engineer in charge, who was formerly employed on the Western Pacific Railway, had occasion to notice its usefulness, and so introduced it into New Zealand.

All the rock building in the tunnel is worked by compressed-air machinery, which is also of American manufacture. Early in the construction of the tunnel, when an accident imprisoned some of the men for about 80 hours, this American machinery pumped fresh air and food into the prison chamber, so that when the men were finally rescued they were little the worse for their trying experience.

Work on the tunnel is proceeding on the same general plan of top headings as in the famous Simplon Tunnel in Switzerland, the top first being cut out, then the bottom, and then all sides trimmed off and finally arched with concrete. The work at the western end now proceeds at the rate of about 12 feet per day. It has been going on for about three years, and may require about five years more to complete. A small water-power plant near the western end drives the machinery, but recently it seems that dry weather has reduced the power below necessary requirement and so interfered with the work.

GROUTING LEAKS IN THE WASHINGTON STREET TUNNEL UNDER CHICAGO RIVER

BY WILLIAM ARTINGSTALL.

In January, 1911, the work [on the reconstruction of the Washington Street tunnel] was sufficiently advanced to permit the operation of street-car traffic. At that time there were numerous leaks through the tunnel walls, which, under the terms of the contract, had to be absolutely watertight. Geo. W. Jackson, Inc., has at this time a force of men engaged in this work, and the method seems to be effective.

A grouting machine, air compressor, electric motor and small derrick mounted on a flat car belonging to the Chicago Railways Co. are run down into the tunnel after midnight. The machine consists of a drum into which the cement and sand are placed and the cover clamped down. Water is then admitted and the mass agitated by means of paddles mounted on a shaft, one end of which, extending through the drum, is fitted with a belt connected to an electric motor. A 2-in. hose is connected to a valve in the drum and leads to the connection at the grouting pad.

Where a perceptible amount of water is coming from one spot, the hole is cleaned out and enlarged to about 2 in. diameter. A felt gasket is then placed around the hole and the flange of a 5-in. pipe placed over the opening The grout is forced through a 2-in. pipe fitted with a tee (capped at one end), which is fastened into the pipe. This 5-in. pipe is used only to hold the pad in place and has a jack screw fitted in one end for bracing against the opposite wall.

The amount of grout forced into the hole depends on the size of the hole to some extent, but some leaks take a large amount of cement. The pressure (about 110 lb.) is not kept on continually, but by applying it for intervals of five or ten minutes with a rest of about the same amount of time, grout can be forced into the leak at practically every trial. The pad and jack are left in place until it is necessary to remove them for the first cars passing through the tunnel at 5 a. m.

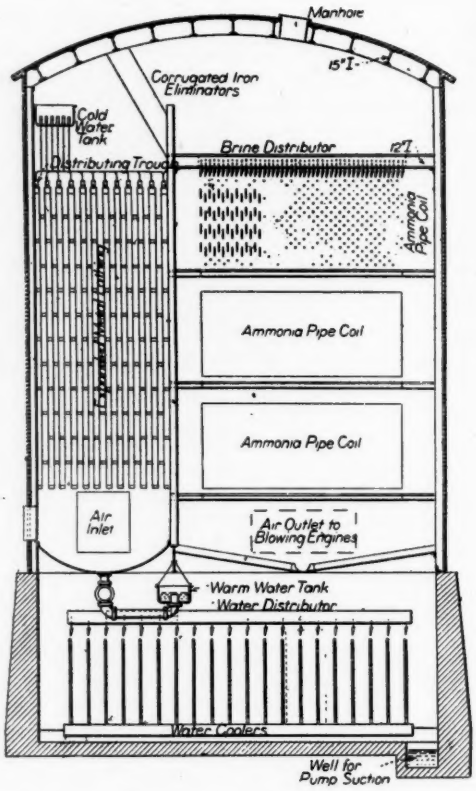
LATER REFRIGERATION METHODS FOR DRY AIR BLAST

BY JAMES GAYLEY.

In the first method of installing dry air plants, the moisture was extracted by passing the air over coils of pipe, which were cooled to a low temperature by the circulation of brine; and while this method has proved effective in practice, cheaper methods have since been worked out.

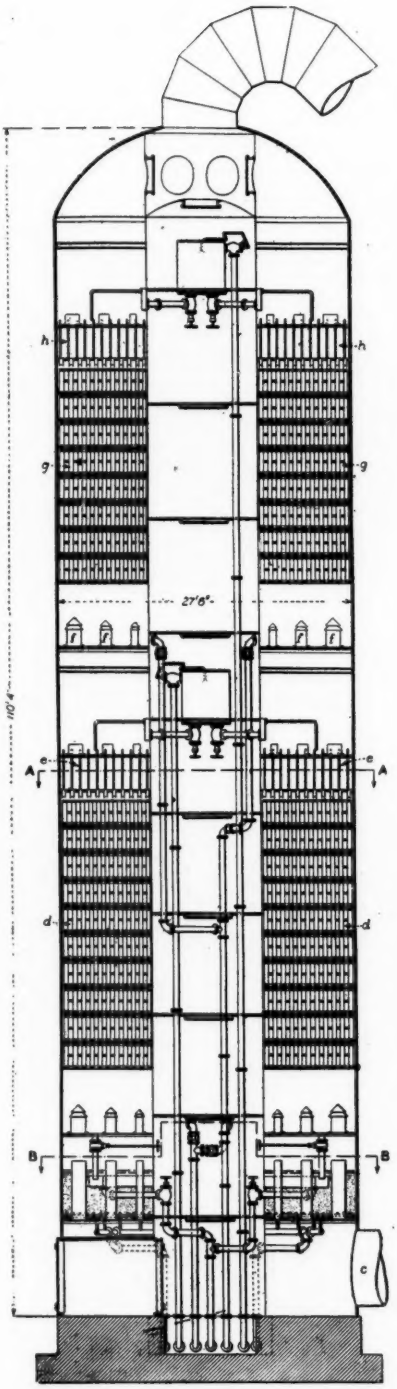
On the principle that it is easier to go from one temperature to another by a succession of steps, rather than by a single step, several methods of applying the two-stage system have been evolved, which, while producing the same results, are more economically operated and can be installed much more cheaply.

Fig. 1 shows a two-stage refrigerating chamber, which represents cooling by a combination of direct and indirect contact. One chamber is filled with screens and the other with coils of pipe. These screens may be made of expanded metal lathing, separated by baffle strips, causing the air to pursue a tortuous course. The air passing up through the screens is met with a descending shower of water, which is cooled as closely as practicable to the freezing point. This removes about two-thirds of the moisture. The air then passes up through moisture eliminators, in which any entrained moisture is removed,



and afterward passes downwardly over the refrigerating coils. A small stream of brine is allowed to flow over the coils, and this film of brine prevents the formation of frost. Consequently the operation of the chamber becomes a continuous one, and the work done in the coil chamber is practically constant, as the air leaves the first chamber at the same temperature. The cooling water with that from condensation collects in the cooling chamber underneath, where it is kept at a practically contant temperature, and the surplus accumulated by the cendensation of the atmospheric moisture can be used for other condensing purposes.

Fig. 2 represents the tall tower type, designed by Bruce Walter, of Pittsburgh, to conduct the refrigeration by direct contact entirely. This has capacity for a furnace requiring 40,000 cu. ft. per min. The air enters at *c* and passes up through pipes to the chamber *d*, which is filled with screens or grids, over which flows a constant stream of cold water. The air is thus brought into intimate



contact with the water and the greater part of its moisture is condensed and removed. Next the air passes through the moisture eliminators *e*, then through the outlet pipes *f* to the brine chamber *g*. In this chamber the air comes in direct contact with brine cooled to a very low temperature, and the moisture is reduce to 1 grain per cu. ft.

The air comes to the brine chamber with a practically constant amount of moisture, and by further cooling additional moisture is condensed and the brine strength is gradually weakened. The revivifying of the brine is not a difficult or expensive matter, for there is plenty of waste heat at the furnace that can be used for this purpose, and a simple apparatus has been devised by Mr. Walter to maintain the strength of the brine, which operates automatically. The center of the tower can be used for a stairway or elevator for use of the workmen, but there is, in the nature of the operation, little to get out of order. The whole method of operation is simple and effective. The tower is built of steel plates, and the cooling fluids come in contact with metal surfaces only, as the insulation is on the outside of the tower.

The work that the fan has to do is that required to lift the air the distance from the fan discharge to the inlet of the blowing engines. The cost of installation by this method, as worked out by several engineers, is about one-half the cost necessary to install under the earlier coil-pipe system, where the moisture was deposited as snow. So the return on the investment is nearly doubled.

In the direct-contact system provision is made for discontinuing the use of the water spray chambers when the natural air temperature, as in the winter season, does not require its use.

In installing the dry-air process, a surplus of refrigerating power above the average requirements is made necessary, to meet the conditions of the high humidity of the summer season, and this provides during the greater part of the year a material surplus of refrigerating capacity, which can be used in other directions. This has been done successfully on a small scale at the South Chicago works of the Illinois Steel Company, in the making of ice for use around the works. There is no reason why this cannot be carried out on a much larger scale, and not only offset the cost

of operating the dry-air plant, but also show an additional profit per ton of pig iron.

At nearly all seasons of the year the humidity is less at night than during the day, and the night surplus of refrigerating power could be used for this purpose. Making of artificial ice can readily be made a by-product of the dry-air process in nearly every locality, and by products are profitable.

There is an abundant supply of condensed steam at all iron works, which could be turned into ice of unquestioned purity.—*Condensed from Iron Age.*

USE OF OXYGEN HELMET IN HIGH TEMPERATURES

By H. H. Sanderson.

During the latter part of August a test was made with oxygen rescue apparatus at Virginia City, Nev., which will, no doubt, prove of considerable interest to mining men, especially to those that have similar conditions to contend with.

The test was made at the Ward shaft, which is operated by the Ward Shaft Pumping Association, being worked exclusively for drainage purposes. The shaft is at present about 2,500 feet deep with stations at various levels.

Nearly every one familiar with the mines in this district knows of the excessive heat encountered, especially at the lower levels, and it was the intention of the writer to test the apparatus under the most unfavorable conditions and ascertain if it were possible to wear the helmet in the very high heat.

The Draeger 1910-1911 two-hour helmet type of apparatus was used. It was decided to make the test on the 2,450-foot level and all air was shut off from this level on the night prior to the test. There being some doubt among the mining men as to the strength of the oxygen cylinder, one was charged to 175 atmospheres pressure, which is 25 atmospheres in excess of the regular charge, and placed in the water at the face of the 2,450-foot level, the water registering 165 degrees of temperature. This cylinder remained in the water for over 2 hours without any evidence of change. After assurance of safety from this source, four men, J. D. Moore, superintendent; H. R. Norsworthy, engineer; Ed. Ryan, state mine inspector; and H. H. Sanderson, were lowered to the 2,475-foot level. The men then put on the apparatus and were hoisted to the 2,450-foot level and all men went to the face of the drift, about 300 feet from the shaft. The temperature was about 134 degrees in the drift. On nearing the shaft on the return trip, some of the party felt that the apparatus was not working properly and all were again lowered to the 2,475-foot level. Here the men were cooled off by means of a spray of water coming direct from the surface, and the apparatus examined.

Prior to entering the mine the helmets had been used on the surface for nearly an hour's time in drilling men in a cave filled with sulphur fumes and it was now decided that the cause for the men's discomfort was due to this fact, as the air regenerators were not fresh when the test began. It was therefore decided to make a second try-out and the party again made preparations to descend the shaft. The oxygen cylinders were recharged and the new air regenerators placed in all apparatus. The helmets were put on before leaving the surface and the men lowered direct to the 2,450-foot level. Here it was found that the heat had increased to about 145 degrees. All went to the drift face and remained on the level about 20 minutes without the least discomfort from the helmet and all of the party agreed that, if necessary, this time could have been doubled. While the excessive heat could be felt very plainly on the body and hands, the face and head were kept cool, this being especially noticeable when the helmets were removed where the temperature of the surrounding air was about 100 degrees.

Members of the party wore very heavy woolen suits and heavy canvas gloves. On removing the gloves it was found to be impossible to bear the hand on any of the metal parts of the helmet or apparatus, and the water and rock were too hot to touch.

The test demonstrated two things: First, that in case of fire or bad air in any of the mines in this district it would be possible to enter the mine and work with the apparatus even though the heat was very great. Second, that while working under such conditions, new air regenerators should be used, and if possible changed every 30 or 45 minutes. The length of life of these regenerators could be lengthened by taking an extra one into the mine and exchanging them about every 15 minutes.—*Mines and Minerals.*

NOTES

To prevent rubber packing from blowing out cut pieces of ordinary wire window screen the size of the packing and place on each side of it. The wire beds itself into the soft packing and holds it in position.

Plans are being formulated for constructing a railway from Cape Town to the top of Table Mountain, at whose base the city lies. The mountain is about 3,500 feet high.

Among the exhibits at the recent automobile show in New York was the largest pneumatic tire in the world. It was a 38 by 8 inch Nobby Tread made at the Morgan & Wright factory in Detroit. The tire was a sample of a limited number made for test work on heavy trucks. Four of these giant Nobbies have been in use on a heavy truck for some time, and beyond a few punctures they have given no trouble. The shoe weighs 100 pounds and the tube 15 pounds.

In the overhead coal storage of a mill at Lawrence, Mass., is a concrete ash bunker, in the form of an inverted pyramid some fifty feet across, made sufficiently air tight to allow a vacuum of fourteen inches of water to be maintained in it. Into this the ashes are drawn by suction from the ashpits. Some time ago an explosive mixture of gas was drawn over from the boilers or generated from the ashpit refuse which became ignited in the bunker and exploded with considerable violence.

Several French physicians advise all airmen attempting altitude records to carry with them a supply of compressed oxygen and an inhalation mask. The cylinders should be provided with a simple regulator allowing about three, four or five quarts to flow out per minute. Distress on account of the rarefied air is not usually felt at altitudes under 13,000 ft., but because of the strenuous nature of an airman's work, it may be felt sooner. Several instances of distress at an altitude of but 11,000 ft. have been recorded in France.

The United States Geological Survey during the course of its topographic surveys, which now cover nearly two-fifths of the area of the United States, has determined a large number of exact elevations and they are now being published in a series of bulletins, each covering either a single state or a group of states. This series of bulletins, though constituting by no means a complete dictionary of altitudes of the United States, gives the exact elevation of many thousands of points, including a large number of towns, hills and mountains of prominence.

It is calculated that 69 per cent. of all railway earnings in the United States is derived from freight, while 23 per cent. is from passengers, and 8 per cent. from miscellaneous sources. About two-thirds of the gross earnings of railways are consumed in their operation, leaving one-third for fixed charges, dividends on stock, and for betterments and improvements. The railways of the United States employ 1,500,000 persons, at a cost of about $1,000,000,000, equal to 35.7 per cent. of the gross earnings.

Blackdamp is often treated as synonymous with carbon dioxide, and this error has led to much confusion. Blackdamp, as ordinarily met with, is simply nitrogen mixed with from about 5 to 20 per cent. of carbon dioxide. It is the residual gas resulting from various oxidation processes in mines and the surrounding strata. The oxygen is consumed, leaving, of course, nearly four times as much nitrogen, while the amount of carbon dioxide formed depends on the nature of the substance oxidized, and on other conditions.

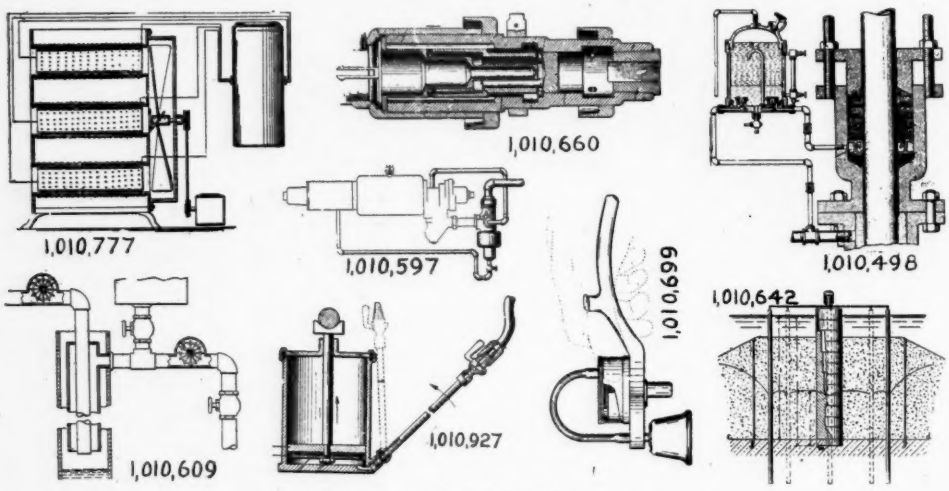
The Meteorological Service of Canada has been making observations of the upper air with sounding balloons since February last, and has achieved some excellent results. Of sixteen balloons sent up, eight have been recovered to the present writing. The altitudes attained have varied from 11.2 to 23.2 kilometers (about 7 to 14 miles). The isothermal layer was found at an average height of 13 kilometers (8.1 miles). The lowest temperature recorded was 70 deg. below zero Cent. (94 deg. below zero Fahr.) at an altitude of about 8.7 miles.

At the Talisman mine, Karangahake, N. Z., a 3⅛-in. piston drill weighing 300 lb., making with ordinary drill steel four hundred 5½-in. strokes per minute with air at 80-lb. pressure, was used for drilling holes for the foundation bolts of a Cornish pump. These bolts were 6 in. diameter. Hexagonal drill steel 2 in.

diameter was used. The starting bit was 6⅝ in. diameter. The finishing drill was 6 in. diameter, 7 ft. long and weighed 84 lb. The drilling was done at the rate of 1 ft. per hour in hard andesite.

A German inventor proposes to enrich the air entering a blast furnace by passing it over barium dioxide, which, at temperatures ranging between 600 and 900 degrees Cent., gives off oxygen. The air is first dried and freed from carbon dioxide and then heated to the required temperature in a Cowper stove. After the supply of barium dioxide is used in the enriching process, the substance is subjected to the action of an air blast at a temperature of 350 to 500 degrees Cent. This regenerates the monoxide, converting it into the dioxide.

It is calculated that in the next three years, for the sinking of the shafts and the drivng of the tunnel sections under Manhattan for the new Catskill aqueduct, the consumption of dynamite will be at the rate of 1000 pounds per day for each of the twenty-four shafts, this making a total of 21,000,000 pounds of dynamite. Extraordinary precautions are taken to safeguard the workers and the city.



PNEUMATIC PATENTS, DECEMBER 5.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

DECEMBER 5.

1,010,456. METHOD OF EVACUATING VACUUM APPARATUS. OTTO SCHALLER, Sudende, near Berlin, Germany.

1. The method of securing high vacua in vacuum apparatus, which consists in preventing the presence therein of vapors of the liquid employed in the exhaust pump used in evacuating it by refrigerating the exhaustion system.

1,010,498. LUBRICATING DEVICE. WILLIAM H. HULTGREN, Philadelphia, Pa.

2. An automatic lubricating device consisting of a closed chamber, an oil discharge passage from the oil space in the chamber provided with a check valve, a pressure supply pipe communicating with the lower part of the chamber and also provided with a check valve, a drain valve at the bottom of the chamber, and a compressed air pipe communicating with the chamber for supplying compressed air from an outside source to the upper portion thereof.

1,010,597. AIR-BRAKE. CARL R. DAELLENBACH, Braddock, Pa.

1,010,609. METHOD OF AND MEANS FOR UTILIZING WATER IN DRIVEN OR DRIVE WELLS TO GENERATE POWER. JOHN C. FOUNTAIN, Parkhill, Ontario, Canada.

1,010,642. SYSTEM OF UNDER-WATER FOUNDATIONS FOR GREAT DEPTHS. EUGENE KNORRE, St. Petersburg, Russia.

1. The process for lessening the air pressure in caissons under great depths of water, which consists in locating in the vicinity of the caisson a series of tubes extending below the bottom of the caisson and continually pumping the water from the tubes.

1,010,660. FLUID-PRESSURE TOOL. ALBERT C. MCFARLANE, Colorado Springs, Colo.

1,010,699. PNEUMATIC MASSAGE - TOOL. CHARLES O. SOBINSKI, St. Louis, Mo.

1,010,726. LOW-PRESSURE TIRE-SIGNAL. JOSEPH M. COLLINS, Gorman, Tex.

1,010,777. OZONIZER. ROSS MORTIMER LEGGETT, Ann Arbor, Mich.

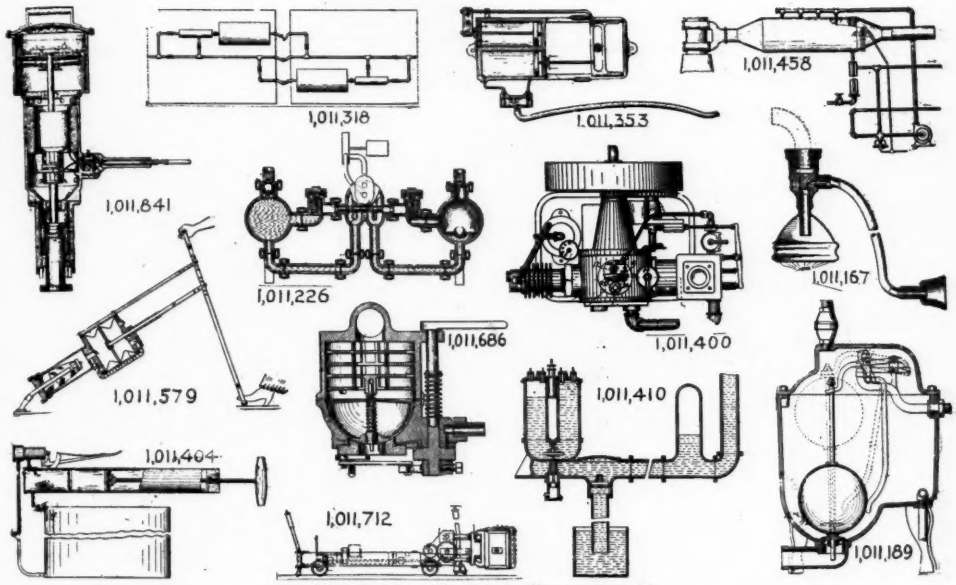
1,010,927. PNEUMATIC JACK. CLARENCE H. LETCHER, San Jose, Cal.

DECEMBER 12.

1,011,167. MASSAGING APPARATUS. HENRY DARK, Philadelphia, Pa.

1,011,189. AIR-COMPRESSING APPARATUS. WILLIAM U. GRIFFITHS, Philadelphia, Pa.

1,011,226. COMPRESSOR FOR REFRIGERATING APPARATUS. GEORGE W. MILLER, Philadelphia, Pa.



PNEUMATIC PATENTS, DECEMBER 12.

1,011,318. VALVE FOR AIR-BRAKE SYSTEMS. CHARLES W. CARROLL, Kola, Miss.

1,011,353. AUTOMOBILE TIRE-PUMP. OTTO W. LINSTRUM, Hoopeston, Ill.

1,011,400. AIR-COMPRESSING PLANT. OSCAR M. BERGSTROM, Minneapolis, Minn.

1,011,404. LIQUID-SPRAYING DEVICE. PETER BRANDT, Chisago City, Minn.

1,011,410. METHOD OF OPERATING INTERNAL-COMBUSTION PUMPS AND COMPRESSORS. HENRY M. CHANCE and THOMAS M. CHANCE, Philadelphia, Pa.

1,011,458. HUMIDIFYING APPARATUS AND MEANS FOR CONTROLLING THE SAME. JOEL IRVINE LYLE, Plainfield, N. J., and EDWARD T. MURPHY, Philadelphia, Pa.

1,011,460. PNEUMATIC TREAD FOR BOOTS AND SHOES. EDWARD MADDOCKS, Toronto, Ontario, Canada.

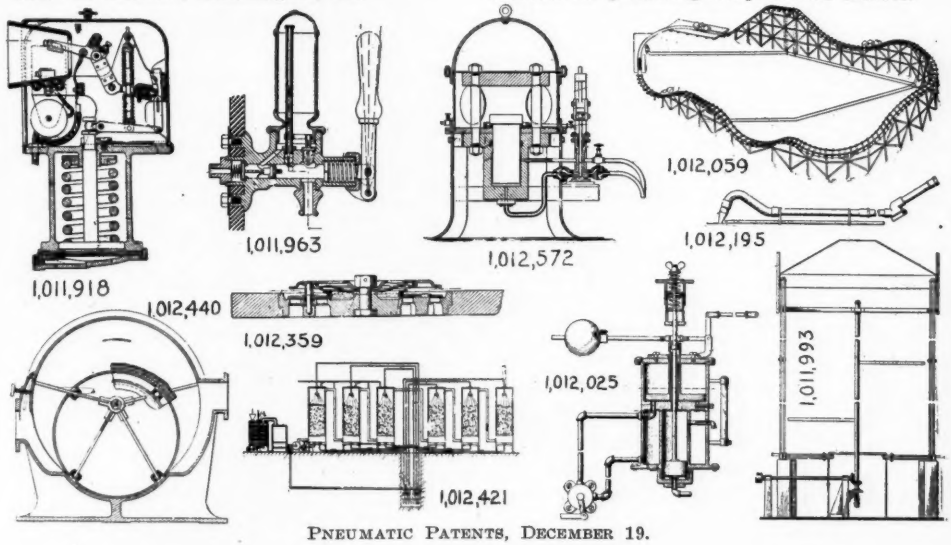
1,011,579. SUCTION CLEANING DEVICE. WALTER S. CHESTON and THOMAS A. MCINTYRE, Jr., New York, N. Y.

1,011,686. FLUID-VALVE. WALTER C. WESTAWAY, Rockford, Ill.

1,011,712. TUNNEL-EXCAVATING MACHINE. JOHN NELS BACK, Seattle, Wash.

1,011,841. PORTABLE ELECTRIC ROCK-DRILL. JOHN ALBERT PIERSON, Pigeon Cove, Mass.

1. The combination of a reciprocating tool chuck, a motor including a rotary and reciprocatory element connected with the chuck, and pneumatic means actuated by the said motor element for producing reciprocation thereof.



PNEUMATIC PATENTS, DECEMBER 19.

DECEMBER 19.

1,011,918. FLUID-PRESSURE GOVERNOR. HERBERT W. CHENEY, Milwaukee, Wis.

1,011,928. MINING-MACHINE. HOWARD N. EAVENSON, FREDERICK D. BUFFUM, and JEFFERSON E. FLEXNER, Gary, W. Va.

1,011,963. APPARATUS FOR THE DELIVERY OF AERATED LIQUID FROM BULK. ALGERNON BROOKER JACKSON, London, England.

1,011,989. VACUUM CLEANING APPARATUS. OTTO H. MOHR, San Francisco, Cal.

1,011,993. DESICCATING APPARATUS. WILLIAM S. OSBORNE, New York, N. Y.

1,012,025. GOVERNOR FOR ENGINES. JOHN C. STIER, Mason City, Iowa.

1,012,059. ELECTROPNEUMATIC BRAKING APPLIANCE FOR RAILWAYS. MAYO H. BURCHARD, Chicago, Ill., and ROBERT P. NOBLE, Portland, Oreg.

1,012,195. SUCTION-CLEANER. FREDERICK A. ENGLISH, Chicago, Ill.

1,012,359. VALVE FOR BLOWING-ENGINES. LORENZ IVERSEN, West Homestead, Pa.

1,012,414. HUMIDITY-CONTROLLING APPARATUS. EDWARD T. MURPHY, Philadelphia, Pa.

1,012,421. MANUFACTURE OF SULFURIC ACID. CARL OPL, Hruschau, Austria-Hungary.

1. The herein described improvement in the art of manufacturing sulfuric acid without lead chambers, which consists in passing the burner gases containing sulfur dioxid under pressure into a system of reaction towers and producing a rapid circulation of nitrous sulfuric acid through the system of feeding compressed burner gases and compressed air to the acid eggs to raise the nitrous sulfuric acid into the towers and to come into intimate contact with the said acid, whereby oxidation of the burner gases is effected.

1,012,440. ROTARY BLOWER. EDWARD P. REICHHELM, Bayonne, N. J.

1,012,572. PROCESS FOR THE EXTRACTION OF OILS AND FATS. WILLIAM SPEIRS SIMPSON, London, England.

The herein described process of extracting oils and fats from vegetable or animal substances which comprises placing a charge of the substance to be treated in a closed chamber, extracting atmospheric air from such chamber, and subsequently compressing the substance *in vacuo* in said chamber to complete the extraction of the oils or fats therefrom and thereby preventing oxidation.

DECEMBER 26.

1,012,578. METHOD OF DESICCATING MILK. HARRY IRVING ANDREWS, Darien, Conn.

1. The herein described process for desiccating milk, comprising the following steps, namely mixing the milk while under a gravity flow with ozone, then subjecting the milk while under gravity flow alternately to the action of heat and cold to evaporate the moisture in the milk, then congealing the milk and forming it into strips, then breaking the strips of milk into small pieces and finally reducing the same to powder.

1,012,693. DISTRIBUTING-VALVE FOR AIR-BRAKES. SPENCER G. NEAL, Los Angeles, Cal.

1,012,694. TRIPLE VALVE FOR AIR-BRAKES. SPENCER G. NEAL, Los Angeles, Cal.

1,012,701. FLUID-PRESSURE REDUCER. THOMAS O. PERRY, Oak Park, Ill.

1,012,720. FLUID-PRESSURE-BRAKE SYSTEM. WILLIAM H. SAUVAGE, New York, N. Y.

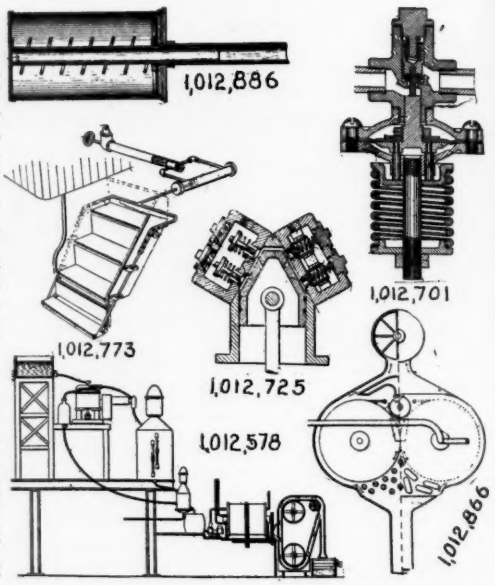
1,012,725. MOTOR AND COMPRESSOR. CHARLES E. SHADALL, Milwaukee, Wis.

1,012,757. BRAKE-PIPE-VENT-VALVE DEVICE. WALTER V. TURNER, Edgewood, Pa.

1,012,758. DUPLEX PRESSURE-CONTROL APPARATUS. WALTER V. TURNER and WILLIAM M. CADY, Edgewood, Pa.

1,012,759. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Edgewood, Pa.

1,012,760. HIGH-PRESSURE EMERGENCY-BRAKE. WALTER V. TURNER, Edgewood, Pa.



PNEUMATIC PATENTS, DECEMBER 26.

1,012,773. PNEUMATIC CAR-STEP. WILLIAM FRANKLIN WEATHERLY, Campbell, Mo.

1,012,800. VACUUM CLEANING-MACHINE. CHARLES BOYER, Marengo, Ill.

1,012,821. APPARATUS FOR SUPPLYING FLUID-PRESSURE. HENRY H. CUTLER, Milwaukee, Wis.

In combination, a compressor, a motor for operating said compressor, an electromagnetic clutch for connecting said motor to said compressor, a generator driven by the motor for supplying current to said clutch, controlling means for said clutch comprising a solenoid having a core and a switch operated by said core to complete the clutch circuit, a maintaining circuit for said solenoid including an economizing resistance, a pressure switch having two operative positions, a switch operated by the core of the solenoid and co-operating with the pressure switch in one position to short circuit said resistance, and another switch operated by said core and co-operating with the pressure switch in its other position to short circuit said solenoid.

1,012,866. ART OF DRYING LIQUIDS. JOHANNES KUNICK, Berlin, Germany.

The herein described method of extracting, in dry form, from liquids, solid substances contained therein, consisting in spreading the liquids in a thin film on the surface of a cylinder, rotating the cylinder continuously, heating the cylinder internally, sucking a current of air through a contracted passageway partly surrounding said cylinder so as to cause the air current to flow over the entire surface of the film of liquid and with such suctional force as greatly to rarefy the same, and so controlling the temperature of the cylinder-surface and the temperature and velocity of the air current that practically all moisture is evaporated during one revolution of the cylinder and the resultant temperature given to the liquid during this drying operation by the cylinder and the air current being such that the substance being evaporated will remain below 100 degrees C. (212 degrees F.).

1,012,886. BLOWER FOR PNEUMATIC SIGNALS. CORNELIUS S. MCQUEENEY, Akron, Ohio.

1,012,898. AIR-VALVE FOR PNEUMATIC TIRES. FREDERICK M. NEAL, Bridgeport, Conn.